AUGUST 1950

Journal

VOL. 42 • NO. 8

AMERICAN WATER WORKS ASSOCIATION

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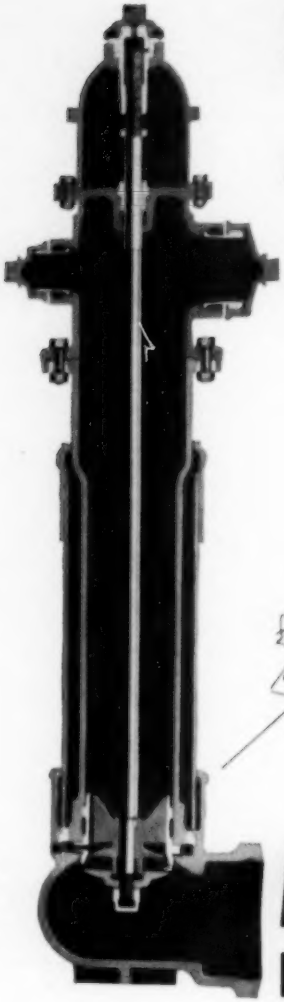

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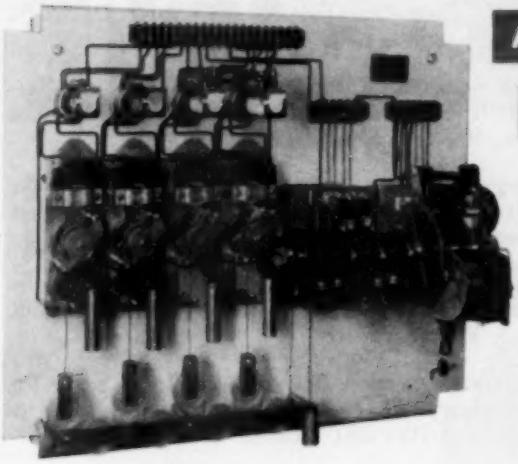

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September 6–8—Minnesota Section at St. Paul Hotel, St. Paul. Secretary: L. N. Thompson, Gen. Mgr., Water Dept., St. Paul, Minn.

7–8—New York Section at Saranac Inn, Saranac Lake. Secretary: R. K. Blanchard, Vice-Pres. & Engr., Neptune Meter Co., 50 West 50th St., New York.

13–14—West Virginia Section at Prichard Hotel, Huntington. Acting Secretary: H. K. Gidley, Director, Div. of San. Eng., State Health Dept., Charleston 5, W.Va.

19–21—Wisconsin Section at Hotel Raulf, Oshkosh. Secretary: L. A. Smith, Supt. of Water Works, City Hall, Madison 3, Wis.

27–29—Rocky Mountain Section at La Fonda Hotel, Sante Fe, N.M. Secretary: G. J. Turre, San. Engr., Board of Water Comnrs., Box 600, Denver, Colo.

28–29—Ohio Section at Neil House, Columbus. Secretary: F. P. Fischer, Sales Engr., Wallace & Tiernan Co., 812 Perry Payne Bldg., Cleveland 13, Ohio.

October 1–3—Missouri Section at Sheraton Hotel, St. Louis. Secretary: W. A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

11–13—Alabama-Mississippi Section at The Battle House, Mobile, Ala. Secretary: John L. Snow, Dist. Engr., Layne-Central Co., 601 First National Bank Bldg., Montgomery 4, Ala.

15–18—Southwest Section at Hotel Roosevelt, New Orleans, La. Secretary: L. A. Jackson, Mgr.-Engr., Little Rock Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

18–20—Pennsylvania Section at Hotel Roosevelt, Pittsburgh, Pa. Secretary: L. S. Morgan, Div. Engr., Penna. Dept. of Health, 415 First Natl. Bank Bldg., Greensburg, Pa.

23–25—Southeastern Section at Fort Sumter Hotel, Charleston, S.C. Secretary: T. A. Kolb, San. Engr., State Bd. of Health, Wade Hampton Bldg., Columbia, S.C.

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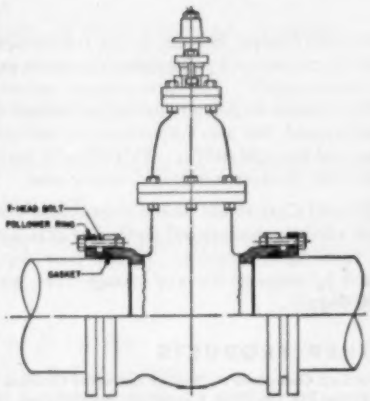

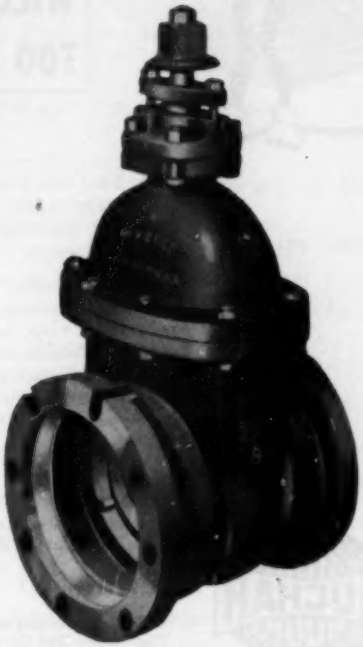

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Journal

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August 1950

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Water Department Annual Reports

Committee Report

A committee report presented on May 26, 1950, at the Annual Conference, Philadelphia, by Melvin P. Hatcher, Chairman, Committee A4.A—Water Department Reports. The other members of the committee are: Roger W. Esty, Lauren W. Grayson, Louis R. Howson and L. S. Vance.

THE Committee on Water Department Reports is charged with "the review of existing annual reports of water works organizations and the making of recommendations for content and style of annual reports." The committee feels that the present report fulfills this assignment. It hopes that it has called attention to principles which will help the water works industry evolve annual report practices that are an improvement over those presently in vogue. The committee is certain, on the other hand, that the present report has not exhausted the subject; rather it feels that improvement in this field is a public relations project of considerable consequence and one requiring and deserving the continuing attention of water works management.

The annual report has come more into its own in recent years, especially in the field of corporate affairs and in the general municipal and some related fields. Its place in the scheme of things, particularly as a public relations instrument, has received critical examination by those responsible for its preparation. Others concerned with its ultimate effectiveness have shown a similar interest. Certain standards of perfection have been developed, and reports have been judged and awards given on the basis of these standards. Surveys have been made in the corporate field to determine and measure stockholder interest. Fresh points of view have grown out of these activities; the annual report in the fields mentioned has been lifted out of the doldrums and has taken on a new look.

In the water works field, some of the privately owned companies have kept pace with this progress in the reports to their stockholders Theirs, however, is a somewhat different problem, and most, but not all, of what is said here

applies more particularly to publicly owned properties.

The reports prepared by publicly owned properties have not matched the progress shown by the reports in the corporate and general municipal fields, although the former have profited, in a few notable instances, by the examples set by others. For the most part, the report of today is not unlike those that were prepared 20 or 30 years ago. The industry has not given much organized attention to its annual reports. The literature includes a few papers on the subject and a few surveys have been made as a means of weighing opinions on matters relating to reports, but each management has usually gone its own plodding way, copying a bit from the practices of others but holding generally to the same report plan from year to year.

The committee feels that the industry can profit from some reorientation of thinking on annual reports and that this revision of ideas should aim at the correction of certain specific shortcomings in present report practices. Mainly, it feels that present reports tend to accomplish too little by attempting too much. Present reports seem to strive to reach two groups of readers that are quite unlike in their respective wants in an annual report. Present reports appear to serve quite well for the professional readers—consulting engineers, those interested in the property's financial standing and other water works managers—except that they are prepared somewhat more elaborately than is necessary for this group. They are not at all well suited to the needs of the nonprofessional readers—an important group in the public relations sense, since it includes the civic and business leaders in the community served. Table after table of statistical matter tends to give an annual report a very low readability quotient as far as they are concerned. They are not likely to be willing to wade through all of the printed matter in such reports in order to find the answers to the few questions they have concerning their water works property.

Conclusions and Recommendations

It is proposed that this twofold purpose be served by a two-part annual report. In this proposal, it is assumed that one part will be a printed report in narrative style, with pictures and drawings to illustrate its story, which will deal with matters of particular interest to the public. The other part is to be a less formal document—produced, for example, by the mimeograph process—including all of the principal statistical and accounting data needed to picture the property's operations and possibly some drawings and explanations to help in the interpretation of these data. The printed report would be distributed mainly among the civic and business leaders in the community served. The statistical report would be the management's own historical record of operations and would be distributed to managers of other water works properties and to consulting engineers and others interested in the detailed results of the property's operations.

It is not meant to imply that present single-report plans are wholly unsatisfactory and should therefore be abandoned immediately in favor of the two-part report. There are certain advantages inherent in a report form that has been in continuous use for a considerable number of years: the data in the report have a consistency of meaning over the years and those relying on the report for information have become accustomed to its arrangement. For these and perhaps other related rea-

sons, the managers of water works properties having such series of reports will be likely to favor a change only if they can feel reasonably sure that there are compensating advantages in a new plan. The committee believes that there are advantages in the two-part plan, but it does not insist that they will always outweigh those to be derived from the continuity of a plan of long standing.

Interest in Annual Reports

Surveys of the effectiveness of corporation reports have induced considerable redirection of effort in this field. It was revealed by one survey "that 90 per cent of the stockholders could not remember whether they did or did not receive a particular annual report for a certain year." One publication commented editorially that "the result [of annual reports] was to most people an effective way of concealing information."

In a very distinct sense, criticisms such as these have been treated by corporate industry as a challenge. They have set about preparing better annual reports. For a number of years, the *Financial World* has been measuring progress in annual reports in terms of a number of important criteria. It reports that there has been a definite trend toward improvement since 1940. In its 1948 survey, 50 per cent of the 2,250 reports reviewed, out of some 4,000 submitted, were classed as "modern," compared with 6 per cent in 1940. One has only to look at the annual reports of a few companies to realize the strides they have made in their perfection.

Annual reports in the general municipal field have shown similar progress, even though their gains are possibly not quite as outstanding and positive as those in the corporate field. It is evident that municipal administrators are aware of the need for improvement in their present report practices and they are making definite headway in that direction. The National Municipal League has awarded prizes for the best reports. The International City Managers' Assn. has prepared an annual report manual (1). The American Institute of Graphic Arts conducts an exhibition each year of the best municipal, state, school and other similar reports and makes awards for the outstanding ones. A paper manufacturing firm has prepared an excellent study of the style trends in modernized municipal reports. The American Public Power Assn. holds a competition each year among its members for the best annual report.

These activities are evidence of the value that business and other groups are assigning to annual reports. Surely no other branch of industry has any advantage over water works properties from the standpoint of the public's interest in the story that can be told in an annual report. Yet the water works industry is definitely behind the pace that is being set by the annual reports of corporations, municipalities and the public and private power companies.

Two-Part Report

Up to the present there have been only a few exceptions to the rule that a water works annual report is a single document. The committee is recommending that the report be subdivided into two separate and distinct parts, with each expected to serve its own particular purpose. It is believed that the two-part report will serve the whole annual report purpose better than does the single report and may possibly be cheaper, or no more expensive, to produce.

The single report has been aimed at a rather wide range of objectives which do not all call for the same caliber and kind of report. In one sense, it was intended to be management's report on its stewardship of the property. In privately owned properties, this message was directed to stockholders of the property; in publicly owned properties, it went to taxpayers in the community or to water consumers taking service from the property. In another sense, the report was intended to be a summary of operating data, serving as a historical record, as a guide for the property's management itself, and as a standard of comparison for consulting engineers and managers of other water works properties.

These two main purposes are not miscible. A report chock-full of statistical data is not a suitable way of telling a stewardship story to stockholders, taxpayers or water works consumers; they are not trained to understand the data and they find it too difficult to separate the wheat from the chaff. The other group of readers—the water works managers and consulting engineers—think of these same data as the chief substance of a report; they need them to measure the results of the property's operations.

The committee proposes, therefore, that water works properties prepare one report for distribution to stockholders, taxpayers or water consumers and another for water works managers, consulting engineers and others with a professional interest in the report. The first is referred to as the "printed report"; it is intended to be the main report, as measured by the number printed and by the effort going into its preparation, and in the sense that it will be designed primarily for local distribution. The other is referred to as the "statistical report"; this report will be produced in smaller number and in a way that will keep its cost at a level lower than that of printed reports.

The point was made above that the cost of an annual report in two parts might be less or no more than that of many single reports as they are now prepared. It is assumed that the printed report will not include more than about 20 per cent of the number of pages required by present report practices and that the statistical report will be reproduced by mimeograph or by some other low-cost method.

Printed Report

The role to be played by the printed portion of the annual report will make it something of a new venture for the managers of most water works properties. Its justification will lie almost entirely in its public relations value. Although a few managers have learned something of the printer's art and something of the problem of preparing material for this purpose through the publication of booklets or brochures, only a very small number have published annual reports relegating nearly all statistical data to a separate report document.

The development of standards for these reports which will make it possible for them to serve their purpose in the most effective way, and will make water works management itself feel that its efforts are well directed, will require some concert of effort within the industry. For the present the guidance in this work must come from what is regarded as good practice in other fields. These include mainly the corporate and the general municipal fields; the studies made of the annual report work in these fields have already led to fair agreement on what is and what is not good practice.

The water works industry will, how-

ever, need to develop its own plans and standards for its reports. Their purpose will be somewhat at variance with that in the fields named and there will be some variations to provide for in the reports of water works properties. Corporation reports are directed almost entirely to their stockholders. Only the privately owned water company reports will be similarly directed. The reports for the publicly owned utilities will be written in a somewhat different vein, even though those to whom the report is directed will be stockholders in a sense. Corporation reports lean rather heavily to the accounting-for-profits side. The publicly owned properties will want to place major emphasis on service to the public. The privately owned companies may make a neat combination of these two main criteria if they wish to have one report serve both their stockholders and their customers. Alternatively, they could direct an annual report to the stockholders and could prepare another report—whether on an annual basis or not—designed to tell their aims-and-accomplishments story to the public they serve. The emphasis in this committee report is on reports for the latter purpose.

There will be some other variations in the purpose of the printed report. The story to be told by smaller properties will not be so much unlike that of the larger ones but it will probably be shorter and somewhat less complex. Some water works properties operate as units within a city government; a report designed to publicize matters not covered by an overall city report will be different from that published by a property operating apart from any other city departments. Properties operated as public water supply districts or under utility boards would fall into the latter category.

The printed report may range from a double-fold spread to a 30- or 40-page document, depending on property size and other circumstances. The water works industry is not too well versed in this type of public relations activity. It will need to build on the experience of others and to accelerate the exchange of ideas within the industry. The latter objective could be accomplished in an excellent way by competitions sponsored by the A.W.W.A. and its sections. Because of their resources, the larger properties are likely to be the first to develop proficiency in this field; the competitions and the exhibits that would accompany them would help this knowledge to filter down to the smaller properties.

It is important that the printed reports be distributed in suitable quantity to the consuming public. A 1946 survey (2) of the annual report practices of six water works properties serving a total of 500,000 consumers indicated that only 36 per cent of the reports were being distributed locally, with an average of only one copy for each 3,300 persons living in the community served. It is urged that these reports be distributed in numbers averaging at least one copy for each 60–80 persons in the community.

Those to be included in a mailing list for the report should be chosen for their interest in civic affairs generally. One water works manager uses the roster of all civic clubs, which should provide an excellent nucleus for the list. Other names could be added from time to time, the aim being to include enough of those likely to be concerned in a competent way with the affairs of the water works utility serving the community to give the coverage recommended above.

The cause of the printed report would be helped, no doubt, if it were

possible to provide concrete suggestions on arrangement, typography, format and style of the report and to set up a check list of the material that might be used in the report. For the statistical portion of the annual report, these points are covered in the appendix to the present committee report, but the water works industry is thoroughly at home in that field and no new arts are involved. The opposite is true for the printed report. The industry needs some more experience with it, as well as more agreement on the aims and purposes of the printed report, before it attempts to compile a manual and check list in detailed form.

A recent article (3) describing a competition in the corporate report field listed seventeen criteria used in the grading process. It appeared that this listing was intended to be somewhat in the order of the importance of these criteria. The last item in the list was "public relations appeal to various classes of readers." In the water works report, it would seem more logical to place this requirement at the head of the list, and this fact has an important bearing on the approach to the problem of composition and subject matter.

Since the report is definitely public relations literature, the plan for its preparation—its style, its composition and all its detail—will be influenced materially by those factors which affect reader acceptance. The mailing lists for the reports will include persons whose time and interest are claimed in more than the average number of ways. Literature seeking to attract their attention comes to their homes and desks in a steady flow. They have learned how to decide at a glance whether a piece of literature is worth their careful attention, and they are likely not to bother with a printed page unless they can get its message quickly. If a water works report is to register with this group of readers, it must impart a maximum amount of information for a minimum amount of reading effort.

Although a report suited to these aims and purposes cannot be described in complete detail, and though the present perspective might be improved upon with just a few years of experience, something can be said about what appears now to be proper subject matter and a proper general arrangement for the report. It may or may not begin with a letter of transmittal; at present this formality seems unnecessary. The main body of the report should consist of an illustrated narrative of matters of most consequence as measures of the property's capacity for service to the public. The departmentalized treatment now used in so many water works reports seems wholly unsuited to the type contemplated here. The report should deal with such matters as property improvements; trends in income and expenses; trends in water consumption, particularly in the home; the effect of softened water—if softening is practiced—in terms of cost and of savings to the public; improvements in service; explanations of practices that have occasioned some misunderstanding by consumers; and other matters of similar import. Finally, the report should be concluded with the two basic accounting statements—the balance sheet and the earnings statement—with or without the accountant's certification or any explanatory notes. One excellent report (Los Angeles Dept of Water and Power) follows these statements with one double page of statistical material. Generally, though, it will be best to avoid statistics unless they are of considerable interest to the public and can be presented in a way that will be understood.

It may be said again that the report must be attractive and readable. Guidance along these lines can be found in the better corporate and municipal reports and particularly in the report manual prepared by the International City Managers' Assn., previously referred to (1). In addition, the printing trade is becoming better and better qualified to advise in these matters. The type should not be less than 10 point,* the page should not be crowded and the subject matter should be keyed to drawings and pictures, with short captions in large, readable type. The report should be liberally illustrated. Color is important. It is hardly conceivable that a report as contemplated here would be published without the use of two or three colors, including the basic black. Some corporate reports use as many as four—black plus the three primary colors, which, when skillfully blended, can supply the entire spectrum. One writer sounds this warning, however: "Color creates attention, not sustained interest."

The report should not be bulky. Reports in the double- or multiple-fold form should fold to fit a standard envelope size. A report which folds to 4 × 9 in., for a No. 10 envelope, is preferable. In bound form, the report should not exceed 30 or 40 pages. Actually, the number of pages should be fixed by the amount of interesting subject matter, and it is likely that the trend will be toward a smaller number.

Statistical Report

The contents and arrangement of the statistical report are described in the appendix to this committee report. As previously stated, the statistical report is designed to serve the management of the property as a historical record and to be distributed to consulting engineers, the managers of other water works properties, persons concerned with the ability of the property to meet its debt retirement schedule and others interested in the property and its operations in a professional way.

Consistent with this concept of its purposes, it is not necessary that the statistical report be prepared elaborately or expensively or in great numbers. Reproduction by mimeograph or some other low-cost process should produce a satisfactory report. It appears that even the large properties should not need more than 150 or 200 copies.

The outline in the Appendix stresses illustrations and explanations. The greatest usefulness of the report will be to management itself. Secondarily, it will provide management with a handy way of answering many of the inquiries it receives. The reports will be several times more useful to those persons not intimately aquainted with the property if drawings showing the arrangement and extent of parts of the property are included. It should be possible to use many of these drawings year after year. The report should conform to the standard letter size—8½ × 11 in.

References

1. Ridley, Clarence E. & Simon, Herbert A. Specifications for the Annual Municipal Report. Intl. City Mgrs.' Assn.
2. Hatcher, Melvin P. The Water Works Annual Report. Jour. A.W.W.A., 38: 1385 (Dec. 1946).
3. Anon. Achieving Perfection in Annual Reports. Financial World (Nov. 2, 1949).

* The size of type used in this article, and standard for the Journal, is 10 point, with an extra point of space between lines (called "10 on 11 point"); 12 points (equal to 1 pica) is ⅙ in.—*Ed.*

APPENDIX

Guide to the Preparation of an Annual Statistical Report

A concept of the purpose of and the reasons for the general plan of the statistical report is included in the committee report to which this guide is appended. Reports built around this concept should show considerable uniformity of range and character of subject matter included. On the other hand, no two properties, however similar their size and operations, would have identical notions of what their respective statistical reports should include.

This outline does not attempt an inflexible answer to that question. Rather it suggests a sequence of subject matter and it tabulates the kinds of data under each subject heading which may deserve consideration as report material. The tabulation is intended to serve as a check list. Some properties will want to include less, some more, than is listed in the outline. The assembly of statistical data under the subject headings as listed or under any headings at all is not considered essential to a sound report plan; rather it is emphasized that groupings—such as purification data, for example—are desirable, and all tabulations or data of any kind should be fully described.

There are certain statistical combinations that are useful as indexes of performance or as evidence of the character of a water works property's operations; included among these, for example, are consumption in gallons per capita per day, customers per mile of mains, production cost per million gallons of water produced and unaccounted-for water. The outline to follow does not place quite as much emphasis on such data as is noted in some statistical report practice. It does seem that population, area served, consumption and per capita consumption should be featured in the introductory part of the report, but all data based on combinations of figures should be referenced in some way to the supporting information.

Certain data are mentioned in the outline as being suitable for presentation in duration curve form. By means of this device, varying quantities—such as turbidity, color or taste, for example—can be shown in terms of their total duration in a given time (for the report, in a year). Although this method of presenting data does require more clerical time than does the minimum-maximum-average plan, it shows the data in their most complete—and, therefore, most useful—form, and it accomplishes this in a minimum amount of space. Even if data are assembled in this way only on the occasion of a special need, such material may well be desirable for the annual statistical report. Management is likely to find the duration curve an effective way of presenting and preserving certain kinds of data.

Consumption analysis data—the number of consumers and the total water consumed against the monthly rates of consumption—are an excellent example of the type of information that can be presented in duration curve form. These data are not listed in the outline because the occasions of their use (usually as the basis for a calculation of the effect of a rate change) are so infrequent as almost to preclude their con-

sideration as an annual report exhibit. It should be kept in mind, however, that it is possible to show graphically on a single page all of the information needed as a basis for a computation of revenue return under any block rate from customers using water under the conditions portrayed in the graph. Data of this sort are likely to be helpful to others contemplating rate changes. It should be emphasized that any such information must be clearly described for what it really is.

I. Description of Property

It is very desirable that the reader be made acquainted, in the first few pages of the report, with the overall aspects of the property whose operations are being reported upon—its source of supply, the character and arrangement of its production, transmission and distribution facilities, and the area and population served. In short, these matters should be explained in a way that will make it possible for the reader to interpret the statistical data in the report and to make comparisons with his own or other properties.

Following are some of the points to be brought out in this introductory portion of the report:

1. *Type of organization.* It should be stated whether the property is operated as a privately owned water company, a utility district or a municipally owned utility. If the property is a unit within a city government, a chart showing the whole city organization plan would be helpful.

2. *Area of service.* Usually the area of service can best be described by a map.

3. *Population served.* If there are subdivisions of any consequence within the area served—inside and outside a city, for instance—the population served in these subdivisions should be shown.

4. *Character, capacity and arrangement of production, transmission and distribution facilities.* Much of the information in this category can be presented to best advantage by means of drawings. Overall capacity data on production facilities will generally suffice here, having in mind that later sections of the report will deal with these facilities in greater detail. Pumping plants should be described by class of operation—electrically operated or steam operated, for example—and by total capacity in million gallons per day. The general character of the treatment plants should be noted—sedimentation, filtration, softening and the like—and the total rated capacity should be given. The source of supply should be described and its location with reference to other facilities should be shown.

5. *Historical.* The historical section of the report should include such information of this nature as would tend to add to the report's usefulness. Properties served by surface supplies from several watersheds might well record the order of development of the several sources. Data showing the trend in demand or in number of customers served, together with other evidences of growth, may be included here.

II. Accounting Statements

The balance sheet and the earnings statement are the basic accounting records. The balance sheet should be accompanied by footnotes explaining any unusual or noteworthy features, such as the character of the funded debt, the

term of outstanding bonds, their interest rates and the current level of total debt service.

Where it can be done, there is some merit to having an earnings or income statement show the current year in comparison with two prior years. Changes exerting an effect of major consequence on the expense of operation should be explained in footnotes.

Amounts to the nearest dollar should suffice for either of these statements.

It is, of course, extremely desirable that these statements conform in all respects to the *Manual of Water Works Accounting* (1), prepared by the Municipal Finance Officers Assn. and the American Water Works Assn.

III. Revenues, Customers and Consumption

If the property records are such as to make it possible, it is desirable that an accounting be made of all revenue by classes of customers and that the revenue data be linked with data showing the consumption of water and the number of customers (as determined by the number of billings divided by the billing periods per year) for these customer classes. A cross reference should be made which will reconcile the revenue in this statement with that in the earnings statement referred to above.

From these data, it is possible to compute revenue and consumption per customer and revenue per unit of water sold. The trends in these indexes are quite important. It is helpful if they can be presented for the report year and two prior years.

IV. Production and Sales Data

An accounting should be made to show the quantity of water produced and the quantity of water registered on customers' meters. The accounting should leave no doubt about the identity of any production or sales figure. Table 1 is an example of the way such an accounting should be made. It is not, however, intended to illustrate precisely the *form* to be used but rather to show the *completeness* of the accounting that is necessary for a proper evaluation of the data. Actually, unaccounted-for water is generally thought of as water not metered, thus excluding water for street and sewer flushing from the accounted-for total. Whatever it may be, the basis for the calculation should be made quite clear in an accounting such as this.

TABLE 1

Accounted-for Water

		mil.gal.
Water pumped from river pumping station		1,812.23
Basin flushing, wash water and station usage	22.12	
Water delivered to flow line		1,790.11
Sales from flow line	1.32	
Transmission losses	2.46	
Total transmission uses and losses		3.78
Water delivered to distribution system		1,786.33
Metered sales to customers	1,485.13	
Street and sewer flushing	6.87	
Other municipal uses	10.40	
Total water accounted for		1,502.40
Total water accounted for, *per cent*		84.1

V. Pumping Station Operations

Each station should be designated by name or location in a way that will

identify it in the property descriptions in the introductory part of the report. The kind and capacity of main pumping units and the source and destination of water pumped should be given for each station.

Such additional data should be included as are needed for a fairly complete account of each station's operations in terms of total operating expense for the year and of the principal indexes of station fuel or power economy. Management should be the judge of whether pumpage is to be reported by months or as a yearly total. The choice will depend to a considerable extent on whether monthly pumpage can be paralleled with data bearing on fuel or power requirements or with other important data, and whether all these data have a significance in monthly form over and above what they would have as yearly totals.

The total dynamic pumping head should be reported for each station. The data for steam-operated and internal-combustion engine–operated pumping stations should include station fuel requirements and the resulting overall station duty. For coal-burning stations, this item is generally expressed as foot-pounds of total station work per 100 lb. of coal burned. For stations using natural gas or oil as boiler fuel or as fuel in internal-combustion engines, the duty should be expressed in terms of the principal fuel—foot-pounds per 1,000,000 cu.ft. of natural gas or per barrel of oil. For mixed-fuel stations, all fuels should be converted to the principal-fuel equivalent. The data for electrically operated pumping stations should include total power requirements and the resulting overall station efficiency; if pumping power is recorded apart from total power, then the resulting average efficiency of pumps should be shown.

For coal used as fuel at any station, the source, heat content, other pertinent characteristics and cost per ton should be given; for oil, the heat content per pound, weight per gallon and cost per gallon or barrel should be given.

For electrically operated pumping stations having a part of the cost of power service based on maximum daily or maximum hourly demand, the data should include a description of the rate and a delineation of the parts making up the total yearly power cost.

Generally, the expenses applying to individual pumping stations will be identifiable in the expense portion of the earnings statement referred to above. If they are not, they should be shown in proper detail in connection with the station operating data. In any event, a calculation should be made to show the total expense per million gallons of water pumped.

VI. Treatment Plant Operations

The extensiveness of the data fitting into this portion of the statistical report will depend on the complexity of the property's water treatment operations. A property distributing water requiring no treatment other than sterilization is likely to have too few data of this kind to justify their being treated as a section of the report, and they may best be included elsewhere in the report, preferably in the "Pumping Station Operations" section.

Properties using more complex forms of treatment will find it convenient to group all treatment data in one section, somewhat in the order suggested below. These treatment data should be preceded by an accounting of water de-

livered to and from the treatment works and by a description of the works. Preferably, this description should include a drawing showing the arrangement of treatment units. The route of water through the various units should be described by reference to the drawing; chemical application points should be identified; retention periods in sedimentation units should be tabulated; and treatment unit capacities should be noted. The water delivered to the treatment plant for the year should be accounted for in this section of the report in terms of known uses or losses, despite any repetition of this information in the introductory portion of the report.

Reference was made at the beginning of this Appendix to the merit of duration curve summarization of data of a certain kind. Considerable data in this section may fall into this category if the increased usefulness, to management, of the data in this form is enough to justify the extra assembling cost. To others, data in such form will be much more meaningful than the commonly employed monthly maximums, minimums and averages. Turbidity, color, hardness and bacterial count in untreated water are examples of the kind of data that will lend themselves to summarization in this form.

Following is a check list, with some comments, of data that may be included in this section:

1. *Maximum daily demand.* A statement should be made in this section of the maximum daily demand in million gallons per day.

2. *Chemicals used in water treatment.* The total weight and total cost of all chemicals should be tabulated for the year.

3. *Filter operations.* Data applying to the total quantity of water filtered, the total wash water, the average filtration rate in gallons per square foot of filter area, the average length of filter runs and the like should be included.

4. *Mineral analyses.* Data should be given reflecting the average mineral concentrations in monthly composite samples of water delivered to the distribution system. If possible, the same data should be supplied for untreated water. If desired, these mineral analyses may be expanded to show constituents determined for sanitary reasons, together with color and odor.

5. *Softening operations.* Usually mineral analyses by months will include the principal data relating to softening. For operations involving varying degrees of hardness in untreated and treated waters, the importance of softening as an element of expense may justify the reproduction of a graphic record of these variations for the statistical report.

6. *Bacteriological results.* Bacteriological data should be arranged to show the improvement in the bacteriological quality of the water effected by sterilization or other steps in the treatment process. Reporting procedures should conform to those prescribed in *Standard Methods for the Examination of Water and Sewage* (2). Many utilities are making routine examinations of samples collected from the distribution system mains and reservoirs; these should be shown by individual locations, or they may be grouped by distance from pumping stations.

7. *Sediment removed.* The effectiveness of sedimentation and filtration units in the removal of suspended matter may be described in terms of the

parts per million, total tonnage or percentage of total solids removed.

8. *Microscopic examinations.* Microscopic examination data apply particularly to algae count and classification; to be most helpful this information must be reported by months.

9. *Color, taste and residual chlorine.* Data on color, taste and residual chlorine may be included with the monthly mineral analyses referred to above, or they may be reported separately in a more complete manner.

VII. Distribution System Operations

The data in this section should be preceded by a description of the distribution system in terms of the range of main sizes, total miles of mains, pumping station pressures, pressure zones, ground level or elevated tank storage, delivery of water for wholesale purposes and related information. If it appears at all essential to an understanding of the data, this description might well include a drawing showing the larger mains and other principal parts of the system.

Following is a check list of data that may be included in the report:

1. *Property additions and retirements.* Data on property additions and retirements may be tabulated in the manner shown below:

Item	Start of Year	Changes During Year		
		Additions	Retirements	End of Year
Miles of mains*				
Hydrants				
Gate valves				
Services*				

* It may be desirable to expand this information to show mains and services by sizes and kinds.

2. *Cost of improvements.* If information on improvement costs is included in the report, it is recommended that a statement be made of whether the work was done by contract or by the property's own forces, and that any other practices bearing on such costs be mentioned.

3. *Main breaks or joint failures.* A report of main breaks or joint failures should include the size of the main, the date of the break or failure, the character of any joint material involved and any other pertinent information.

4. *Hydrant operations.* Any hydrant maintenance or hydrant moving data should be mentioned. Practices bearing on hydrant maintenance costs should be described.

5. *Services.* Under services, any data regarding the cost of constructing and the expense of maintaining services should be included, and practices bearing on these costs or expenses should be described.

6. *Meters.* Data on meters should include the number, size and kind of meters used in the service of customers and any information on the expense of maintaining these meters. Any data of the latter character should be cross-referenced as clearly as possible to the expense portion of the earnings statement previously discussed. Where possible, meter maintenance expense should be shown by meter sizes and should be subdivided into material, labor and other costs. Practices relating to meter ownership, repair and removal should be described.

VIII. Automotive Equipment

The expense of maintaining and operating automotive equipment will not be identifiable as such in the earnings statement in Sec. II above; the *Manual*

of Water Works Accounting (1) requires these expenses to be accumulated in a clearing account and charged from there to the proper expense account in proportion to car mileage or hours of use. Therefore, this expense, in its original form (as labor, gasoline, oil, parts and shop overhead) should be shown in this section. It may be reported for individual units or by groups of units of a similar kind—pickup trucks and 1½-ton trucks, for example—with data on time or miles of use by divisions within the property.

If depreciation is given as an element of expense, the basis for the allowance should be explained.

IX. Personnel

The section on personnel should include all data pertaining to the number of employees, salary and wage schedules, pension matters, personnel rules and practices, and employee records of accidents, sick leave and similar matters.

The organization chart provides a most effective way of presenting information on the total number of employees required to operate and maintain a property. The chart can be made to show the average number of employees per year or the number at the end of the year. Generally, the latter will suffice; if desired, this information can be expanded to show the number of employees by position and their total or their group costs for the year.

Following is a check list of additional data that may be included in this section:

1. Sick leave—total number of days, average per employee, average length
2. Number of employees discharged
3. Number of resignations
4. Number of suspensions
5. Number of appointments
6. Number of accidents reported
7. Number of accidents causing lost time
8. Time lost on account of accidents

X. Collection Division Operations

It is important that the data pertaining to the property's collection operations be supplemented with explanations of any practices bearing on them. For instance, the time allowed for bill payments should be mentioned in connection with the data on the number of delinquent bills.

Following is a check list of data that may be included under this section; except where noted, yearly total information should suffice:

1. Number of active accounts, by classes of customers (by months)
2. Number of bills rendered, by classes of customers (give billing period)
3. Number of delinquent bills rendered
4. Number of inspections
5. Uncollectible bills
6. Abatements and adjustments

XI. Rates

A complete statement of rates should be given.

References

1. *Manual of Water Works Accounting.* Am. Water Works Assn. & Munic. Finance Officers Assn., New York (1938).
2. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).

Living With the Atom

By Norman R. Beers

An address presented on May 23, 1950, at the Annual Conference, Philadelphia, by the late Norman R. Beers, Editor, Nucleonics, New York. (*An obituary notice appears on p. 10 P & R, this issue.*)

YOUR younger sons and daughters may bring home notebooks from school which contain, side by side, paragraphs on the dangers of the H-bomb and the dangers to be encountered in a hot kitchen. This juxtaposition is apt, for the burns that may be anticipated from A- or from H-bombs and from hot surfaces or scalding fluids in the home are entirely similar and each may be fatal.

Essential though it is, however, that school curriculums refer to recent as well as to the older technologies, the more thoughtful among us will also recognize that man has been living with the atom from the beginning and that he will continue so to live until the end of (his) time. It is not the existence of atoms that is new, nor yet that atoms have not been well known and respectable in science for many years. But the use of the atomic bomb on August 6, 1945, over Japan remains one of the hottest news subjects for mankind; and it is understandably difficult to insure the attention either of the public or the engineer to the essential work to be done with atomic energy for peace, completely aside from any possible use in war or preparation for war.

This condition is due, partially at least, to the tacit understanding, even among many professional men, that "you cannot teach an old dog new tricks." In my experience as editor of *Nucleonics*, I have been frequently and profoundly shocked by my editorial colleagues (and other engineers) who have truthfully stated that they know nothing about atomic energy. There seems even to be a certain pride of ignorance. Increasingly large or bizarre headlines in the newspapers still serve to bring readership to war, civilian defense and secrecy-versus-security talk, while the more factual information, even that presently being released by the authorities, is either not printed or limited to small type on inside pages. I think we may reasonably conclude that this disposition of material is usually determined by the editor in the way best calculated to please and retain his readers.

Learning Capacity

Of particularly great importance at this time, when technical and scientific knowledge is disseminated rapidly among those who wish to learn, is the fact, established primarily by the psychologist Thorndike, that adults have a capacity to learn. It is no longer possible to rest easy in the belief that childhood is the time of learning and adulthood the time of having learned. In fact, in many professions, the man who attempts to carry on his business using only what he learned in school and university will be forced into early retire-

ment from the scene. H. A. Overstreet has put the matter beautifully in his book, *The Mature Mind*. It is a threat to our society to have adults stop learning, "to have them become fixed in an unhappy or a complacent unchangeability in a world where they are constantly confronted by the problem of change."

I want now to admit, and to stress the admission, that none of us who have had little or much to do with the Manhattan District or with the U.S. Atomic Energy Commission wishes all of you to become expert in his own specialty. Each of us, naturally, recognizes the vast importance of his particular subject but, I trust, realizes that other busy men cannot devote the time needed to become expert in all things. But as you have reason to expect me to become familiar enough with the elements of water and sewage works so that I can vote intelligently for new and needed installations, so do atomic scientists reasonably expect you to acquire what we will call, along with the late H. G. Wells, an "irreducible minimum" of knowledge about atomic energy.

The precise limits of the irreducible minimum of knowledge about atomic energy cannot, and need not, be set, since the minimum clearly varies from person to person. If I may go on record with an overall recommendation, I will suggest that the literate citizen may be expected to be able to read a comic strip prepared under the auspices of Groves, Dunning and Musial and distributed widely by the AEC. The piece is called "Dagwood Splits the Atom." I would not expect every good citizen to remember everything he reads in this document, but he ought to be qualified to read it and he will profit if he does.

For those who, at the recommendation of friends or by their own critical faculties, can overcome the distrust natural when one learns all he knows about an organization from publications of the organization itself, the semiannual reports of the AEC are excellent storehouses of information. I recommend that the AEC bring together and publish, with a good index, the seven such reports now printed. The reports can be obtained separately from the U.S. Government Printing Office; they should be available to every citizen of the United States of every age, through a school, church, rental or personal library, in bound form, as a valuable record and source of information on atomic energy handy to all. Future reports should be treated similarly.

More technical information on atomic energy is also periodically available to all through other publications of the AEC, in the pages of various journals devoting some space to the subject and, last but by no means least, in *Nucleonics*. In addition, a number of books on the subject have been published. The first to appear was the now famous "Smyth Report" (1), and the AEC-sponsored *Source-Book of Atomic Energy*, written by Glasstone, will soon be available at a more readable level for the nonscientist. Since any of these sources of information gives many more references, I will leave my first major point, which is that you, as adults, not only can and ought to learn something of atomic energy beyond what appears in the daily press, but that you will find the necessary information within easy reach.

Need for Daring

It sometimes becomes essential to introduce startling or daring ideas even

in science. Eddington, for example, conveys important information by remarking: "A nucleus (atomic) is composed of protons and electrons in the same way that an omelette is composed of eggs; that is to say, when the omelette appears on the table, there are fewer eggs in the larder." I will not labor this analogy because I do not think it is essential that many people worry unduly about what theoretical physicists mean by elementary particles. For even in this "Atomic Age," the ordinary man is concerned more with things on the macroscopic than on the microscopic scale.

My second major point is simply an essential agreement with the thesis of a letter published by the *New York Times* in which Harold C. Urey urges that now is the time for a more daring approach in atomic energy development. Urey writes, in part:

> A new discovery can be more rapidly exploited by people who believe, try, make mistakes, but believe and try again, than by people who are so sure that they know beforehand just what cannot and should not be done. Many believed and tried in the development of the automobile and airplane industries, and a few succeeded.
>
> We should establish the same sort of possibilities in the field of atomic energy. A young man should be able to make a reputation in atomic energy without the nod of a federal appointee, and an industrial company should be able to take a risk and win or lose on its ability to deliver a profitable process or invention.
>
> Successful peacetime development of atomic energy will come with higher probability and more quickly from men who believe they can accomplish this end in one, two or five years than from those who know it cannot be done in twenty-five years.

It may surprise you for a moment when I say that some such successes have been counted already in the United States. So far as I know, there is no private nuclear reactor in operation; the ownership of fissionable material is determined by statute. But the phrase "atomic energy" surely includes all of the work areas in which the AEC engages; and, on this basis, the field of instrumentation, for example, has shown several moderate successes. Moreover, with but little supervision from the AEC, a firm may build and operate a radiochemical laboratory for profit. Several have done so, and others are under construction. Radioactive isotopes are available from the AEC. Instruction in the safe handling and disposal of radioactive materials may be obtained from the AEC and from an increasing number of colleges and universities.

John Z. Bowers, who in November will become head of the medical college at the University of Utah, has recently stated: "We must not be dissuaded by atomic bombs and their dreadful implications from the simple fact that, at this date, *atomic energy has saved more lives than it has destroyed.*"

Members of the American Institute of Architects, in their May 1950 meetings, have urged speedier and more comprehensive planning for the orderly dispersal of American cities, a concept of far-reaching sociological and economic importance even if introduced as the only obvious defense against atomic warfare. Other members of the A.I.A. oppose the plan with equal vigor and brilliance.

Some people call for the government to establish liaison between the Dept. of National Defense and local governments, to furnish a steady stream of information covering modern defense

and the probabilities of attack, and to prepare to distribute information through theatres, schools, radio networks and so forth that will instruct everyone on what to do in the event of attack. Others of equal integrity, especially when charged with considerable responsibility, have elected to postpone decisions or to prevent their dissemination to the people.

Whatever the viewpoint of an individual about specific suggestions made by this or that expert and headlined in the daily newspapers, one is impressed by Bernard Baruch's convocation address at the College of the City of New York, in which he stated: "Washington today is a dismaying example of Dryden's observations about those who 'think too little and talk too much.'" The important questions require a personal evaluation by increasing numbers of people as various authorities deliver contradictory opinions as facts. *Men who are competent to do so would serve their fellows and themselves if, especially at such times, they replaced "authority" by reason in the formulation of their own opinions.*

But important though radioisotopes, medical applications and city dispersal are, it would appear that Urey is really writing of the possible development of atomic energy for industrial power purposes when he urges a more daring approach. Whether or not I interpret the letter with absolute accuracy is of no great moment; the important thing is that the time has come to think about possible changes in the Atomic Energy Act of 1946, changes which would permit cooperation of the people with their government along the lines suggested by Urey. A new chairman of the AEC will soon be appointed; new personnel are on the commission now; and the elections of 1950 and 1952 may remove from office others who are disinclined to look for changes before they are smacked in the face. One must also make the best predictions possible concerning both our and the Russians' probable scientific and engineering advances to see whether our best is, indeed, good enough, or whether we cannot improve by the more daring approach.

Benefits of Atomic Energy

In the preceding discussion I have given facts and opinions to buttress the assertions that: [1] adults have a capacity and a duty to learn; and [2] now is the time for a more daring approach in atomic energy development. The remainder of this paper will be a general survey of the good that might result from atomic energy. In short, the author now requires the aid and assistance of his readers if any real gain is to be made.

I am not in possession of any recently declassified information on atomic energy which, by the grace of Washington, I can now pass along to you. I cannot report that the developments I will suggest have been accomplished, for, had they been accomplished already, every one would know about them from many sources. With the active interest of such an organization as the A.W.W.A., I think some of the things I suggest will be more quickly accomplished than they would be without it.

Aside from the "bomb," two outstanding facts about atomic energy are: [1] with presently accepted science and engineering knowledge and skills, nuclear reactors can be built which will provide enormous sources of energy as heat at relatively low temperature in the reactor fuel; and [2] air-cooled reactors, "atomic explosions" and pos-

sibly other devices and phenomena of the atomic age actually do release sufficient radioactivity so that "tracer experiments" may be performed in the free atmosphere.

My suggestion with respect to industrial power from atomic energy is simply that we have paid entirely too much attention to proving (or disproving) that we can or cannot obtain power *economically in regions that are already pretty well supplied with power and for use in industries that require shafts to be turned*. It would not be wise at present to install a large nuclear reactor at say, Times Square, New York, for any purpose. Safe though the reactor can be made, it would seem better to keep it from the center of so many millions of people.

Desalting Sea Water

I would, however, like to see several nuclear reactors constructed, using either current design or minor modifications, in locations where the water problem is acute and where cool salt water is available in quantity close to shore. Such conditions coexist in numerous places over the earth. An auxiliary source of power of conventional type would be necessary to turn a number of shafts—perhaps a few thousand kilowatts would be required—but from the reactor itself would be obtained the equivalent of many megawatts of power in the evaporation of water from the ocean, in the operation of steam-jet pumps to lift the water (both salt and fresh) and in space heating, if desired. Thermodynamically the device would not be very efficient, but that is of no consequence if uranium is available.

In addition to doing much for the water problem of the area, the installation proposed would secure valuable elements from sea water, provide additional production facilities for plutonium, serve for additional reactor research and (if power from shafts is still wanted) pump water up mountains into reservoirs from which ordinary hydroelectric power can be obtained. There do not seem to be any unsolved engineering problems in the proposal, since each component part already exists somewhere for one purpose or another. One would expect to improve designs and to increase efficiencies with experience of the whole installation. But a good workable plant could be constructed in relatively short order.

The proposed use of a nuclear reactor as a gigantic heat source at low temperature is so simple that it has possibly been reported elsewhere previously. I have not seen it; and I would be happier about the United States' position in atomic energy for peacetime uses if an organization such as the A.W.W.A. were to begin active demands for this or a similar development. The current water problem within the United States almost "requires" some such treatment.

Atmospheric Pollution

Atomic energy and atmospheric pollution may be associated almost as simply. The developments up to now are not so well known and widely appreciated as are those connected with the reactor as a low-temperature heat source, but they are nonetheless straightforward, and available in unclassified reports from previously designated sources. The results are partially of interest to your daily water problems, as those of you who have followed New York City's investigation of "rainmaking" will know. Not even Wallace E. Howell, New York's "rainmaker," would promise to produce a rainstorm at some

random time in the future; but any intelligent man, meteorologist or not, who will read the literature and watch some experiments becomes convinced of the interdependence of precipitation and the state of the atmosphere, in part specified by the distribution of pollution in it. Both the weather and climate of the earth change, and we need to learn more about how the changes occur.

The important research device that has been made available to assist in learning the relations between atmospheric pollution and weather is illustrated by the reported fogging of photographic plates by radioactive particles that had been carried more than a thousand miles by the wind from the first atomic bomb explosion in New Mexico. Also, on a more nearly continuous basis, will be the monitoring of radioactivity reaching downwind areas from the air-cooled nuclear reactor nearing completion at the Brookhaven National Laboratory. It will do no harm to point out here, as it has been pointed out elsewhere many times, that this delicacy of experimental excellence is due to the fact that instruments for the detection of radioactivity are extremely sensitive in comparison with dosages of radiation that can harm personnel. And this situation, much to be desired in any experimental work, will continue unless and until the (natural) background count of radiation is increased generally by a factor of ten or so at sea level.

Through studies of what seems fated to be known as "rainmaking," in correlation with a complete description of the large-scale movements of air at both the earth's surface and aloft, it will be learned how to change the rainfall appreciably over large areas. Special study must also be given to the washing out of particulate matter from the atmosphere. The effects of changes in rainfall and of possible contamination of ground water by radioactive particulates washed out by rain need not be stressed in this paper.

The pollutants which man discharges into the atmosphere know neither state nor national boundary. It is important that this fact be recognized. It is important that the effects of various polluting agents be known, whether they are put into the air by accident or willfully. And it is important that these things be known by a sufficiently broad and significant portion of the people, so that if the results of such atmospheric pollution (possibly "meddling" is a better word) are inevitably to be too unpleasant for them, then action can be taken to stop the irritant while there is yet time. *It is unnecessary to let our atmosphere become as polluted with radioactive matter as portions of it are with stable isotopes, and as many of our streams are polluted, before doing something about it.*

I believe the essence of my thinking about living with the atom can be summarized by saying that the familar adage, "the three major water problems are too much, too little and too bad," must be refuted by the knowledge and action of responsible men and women. Such persons can prove that adults have a capacity to learn; that the daring of the pioneer spirit still exists in America and can be applied in technology as well as it formerly was in opening up the West; and that new, undreamed of uses for atomic energy and atomic power will soon be ours.

Reference

1. Smyth, H. De W. *Atomic Energy for Military Purposes.* Princeton Univ. Press, Princeton, N.J. (1945).

Control of Aquatic Growths in Impounding Reservoirs

By Eugene W. Surber

A paper presented on May 23, 1950, at the Annual Conference, Philadelphia, by Eugene W. Surber, Upper Mississippi–Great Lakes Drainage Basins Office, Div. of Water Pollution Control, U.S. Public Health Service, Chicago.

THE relatively recent development of such weed control agents as 2,4-*D*, 2,4,5-*T* and certain hydrocarbons has brought up the question of their suitability for controlling submersed weeds in impounding reservoirs and plant growths on the shores and embankments. The author's previous experience has been in the field of weed control in and about fish hatchery ponds and small artificial lakes. One of the most effective herbicides for submersed plants in hatchery ponds, sodium arsenite, could not be used in water supply reservoirs. Inorganic fertilizers applied at the rate of 25–50 lb. per acre in small, artificial recreational lakes increased the growth of microscopic plants in the surface waters, thus shading out the submersed plants which formerly grew to the surface and interfered with boating, fishing and swimming.

In water supply reservoirs, it is recognized that the problem is very different, because certain algae impart odors or tastes to the water. Any fertilization of impounding reservoirs would definitely contribute to increased algal growth, and methods of preventing it have long been recognized. Recently Hudson *et al.* (1) discussed crop rotation and other means to prevent siltation in reservoirs which likewise prevent fertilization.

Control of Submersed Plants

The use of the phenoxyacetic compounds 2,4-*D* (2,4-dichlorophenoxyacetic acid) and 2,4,5-*T* (2,4,5-trichlorophenoxyacetic acid) in large bodies of water or in hatchery ponds is not practical at present because of the exorbitant expense involved. Effective control in hatchery ponds could not be obtained with these compounds at costs under $100 per acre, whereas objectionable submersed weeds could be controlled with sodium arsenite, without direct danger to the fish, for only a few dollars per acre. Moreover, there is a probability that 2,4-*D*, for example, would impart an objectionable flavor to the water, although, to the author's knowledge, direct information on this point has not yet been collected. At Leetown, W.Va., a pond adjacent to, and in elevation slightly above, an experimental farm pond from which fish were being removed by angling was sprayed with a 2,4-*D* formulation to destroy the submersed weeds. Sufficient water seeped from this pond into the experimental farm pond below to make the sunfish and bass caught there unpalatable.

The sodium salts of *2,4-D* and *2,4,5-T* are readily dissolved in water and are easy to handle, but such large quantities of these products are required for underwater weed control that they are not practical to use.

Surber, Minarik and Ennis (2) showed that the common water weed, *Anacharis canadensis,* and other submersed aquatic plants could be killed by 5 and 10 ppm. of *2,4-D*. Gerking (3) estimated that the *2,4-D* concentration required for the control of submersed aquatic plants lies between 10 and 100 ppm. and is probably on the order of 25 ppm. He estimated that it would cost $67 per acre-foot of water to destroy the weeds at the prices then existing.

Hydrocarbons such as orthodichlorobenzene, trichlorobenzol, dichlorobenzol and naphtha have also been employed in weed control. They are spread over weed beds with special equipment for subsurface spraying at rates varying from about 20 to 50 gal. per acre. In laboratory experiments, these compounds have been found highly toxic to fish. When employed at the levels required for submersed-weed control, each of the hydrocarbons killed fish in aquarium experiments performed at Leetown.

The author has had limited experience with ammonium sulfamate, but, in experiments in small dirt-bottom ponds at Leetown, 10 lb. per acre failed to control submersed plants, particularly water lilies (*Nymphaea odorata*). In aquarium experiments, 10 ppm. arrested the growth of *Anacharis canadensis* and *Potamogeton crispus* but failed to kill them. It was not toxic to fish at this rate. The U.S. Bureau of Reclamation has found this compound particularly valuable in controlling woody plants such as willows and poison ivy (4).

The aniline dye, nigrosine, was employed by Eicher (5) to control weeds in two Arizona lakes. Applications of 10 lb. per acre of water surface were used, with the maximum results following as much as a year later. The natural currents in the lakes treated were of great value in distributing the dye throughout them. In a recent study (6) of the biological effects of this dye upon plankton and bottom fauna, it was found that nigrosine was virtually harmless to the entomostracan, *Daphnia magna,* which successfully survived a five-day period of exposure to quantities as high as 7.2 ppm., or 20 lb. of nigrosine per acre-foot of water. In dirt-bottom ponds treated at the rate of 10 lb. of nigrosine weekly for four weeks in August 1949, the population of bottom animals increased. The zooplankton, already poor in numbers and made up mostly of a few species of rotifers, decreased in abundance in two out of three ponds for which quantitative studies were made.

Small quantities of nigrosine in large bodies of water apparently have far-reaching effects. It is suggested that water works engineers and limnologists explore this field further, to determine how effectively this dye might be used in weed control in large impoundments. In hatchery ponds where applications are made early in the operating season, 10 lb. of nigrosine in an acre of water 3 ft. deep will probably give good control. This amount (equivalent to approximately 1.2 ppm.) can hardly be detected in a glass of water, but there is a possibility that a smaller amount might be effective in reservoirs.

In experiments conducted at Leetown during the past winter to determine the rate of absorption of the dye by different quantities of the same kind of plants (*Anacharis canadensis*), a photelometer with a red filter (Cenco * No. 87309C) was found very useful in determining residual nigrosine. Standards containing known amounts of nigrosine were employed in the preparation of an analytical curve. A photelometer may be used in reservoir operations to check the amounts present, since quantities of nigrosine as low as 0.03 ppm. can be determined.

Of all the comparatively new chemical agents known to the author, nigrosine offers the only safe and economical control method which may possibly be of practical value against submersed aquatic plants in impounding reservoirs.

Control of Shore Growths

It is well known that the growth regulators, 2,4-*D* for herbaceous plants and 2,4,5-*T* for woody plants, are of great value in the control of objectionable terrestrial flora. The first of these compounds has been used extensively on lawns in 0.1 per cent solutions containing 1,000 ppm. of the acid. Good coverage of lawns has usually been obtained with 100 gal. of liquid. The amount of the acid powder actually applied is 1 lb. per acre if an 80 per cent 2,4-*D* formulation is used, or 1¼ lb. per acre if 70 per cent 2,4-*D* is used.

Hall and Hess (7) found 2,4-*D* in solutions of 0.1 to 0.2 per cent, at rates as low as 1–3 lb. per acre, adequate for the control of succulent broad-leafed plants, such as jewelweed, plantains, arrowheads, water willow (*Dianthera americana*) and others, but it is presumed that water works superintendents, like fish culturists, would usually be more concerned with the eradication of erect species, such as cattails, soft-stem bulrushes, bur reeds and spike rush, and the floating-leafed aquatics, such as water lilies, water shield and water hyacinths. These plants, particularly the erect varieties, build up marshes about the shores of impoundments and reduce their water storage capacity.

Knowledge of the effectiveness of various 2,4-*D* and 2,4,5-*T* formulations in the control of emergent aquatic plants, willows and the like is still far from complete, but much information has been obtained from recent experimental work with marsh and aquatic plants.

One of the requirements for effective treatment with these compounds is thorough coverage of the plants under the proper conditions. Treatments are more successful in warm, clear weather. Effective control of cattails has been obtained by spraying these waxy-coated plants with an oil formulation containing amounts of 2,4-*D* as low as 0.5 per cent, dissolved in tributylphosphate and kerosene, fuel, diesel or other light oil. Best results are achieved by applying the spray when the plants are actively growing and before they have formed spikes. Cattails are seldom eradicated by a single application, because they propagate by means of rhizomes, or underground stems, from which new shoots arise.

Water spray solutions must generally be used in larger quantities than oil sprays. Although 20–50 gal. of an oil spray might be sufficient to treat an acre of water surface covered with pond scum algae, duckweed or cattails,

* Central Scientific Co., Chicago.

100–200 gal. of a water spray might be required for effective control because of the higher surface tension of the water droplets and the ease with which they are shed from the leaves and stems of plants.

Plants with waxy coatings, such as water lilies, require an oil spray for effective treatment. In dealing with water lilies, the author has found it necessary to lower the water level until the petioles of the lilies, as well as their leaves, are exposed. Even then, a minimum of three treatments is required to eradicate the plant because of the reappearance of new shoots from the massive subterranean rhizomes.

Oil sprays, on the other hand, are more dangerous to fish because of the toxicity of tributylphosphate (TBP), an active herbicide, which is used as a solvent for *2,4-D* before its dilution with kerosene or other oil carriers. TBP is toxic to fish in concentrations greater than 15 ppm., and kerosene and other oils are also toxic, particularly when they have been emulsified. Care should be exercised in handling TBP because it is irritating to eyes and skin. Any which may get on the person should be removed promptly with soap and water.

The cosolvent, triethanolamine, used to dissolve *2,4-D* prior to its dilution with water, does not appear to be toxic to fish.

A commercial solution consisting of 35.0 per cent *2,4-D* and 17.5 per cent phenylacetic acid at 7 pints to the acre has proved very effective against water lilies and practically all of the common emergent aquatic plants about hatchery ponds. Gladys S. King (8) noted that auxin (plant hormone) moved to the basal buds in water hyacinths when treated with *2,4-D*. The commercial formulation contains potassium chloride and ammonium phosphate, which are added to inhibit the effect of the substrate. Eosin is present as a catalyst. This formulation has the advantage that it can be diluted with water, and the disadvantage that phenylacetic acid has a very disagreeable odor.

The most convenient forms of *2,4-D* and *2,4,5-T* now on the market are the sodium salts of these closely related compounds (sodium di- and trichlorophenoxyacetate). These chemicals are very soluble in water and are effective against plants without waxy coatings, such as willows, bur reed, smartweeds, marsh marigolds, water cress and veronica. Directions for their use are contained on the drums in which these materials are sold. These agents are powerful and, like DDT, can be applied from the air by planes.

TABLE 1

Composition of 2,4-D Spray Solutions

Solution No.	2,4-*D* (Acid Powder)		Cosolvent		Carrier (to make 25 gal.)
	per cent	Weight *lb.*	Chemical	Volume *qt.*	
1	1	2	tributylphosphate	2	light oil, kerosene
2	1	2	triethanolamine	1	water

Tables 1 and 2 may be of use to water works superintendents in preparing 2,4-*D* formulations at reduced costs. 2,4-*D* is a white powder, relatively insoluble in water, but readily dissolved in tributylphosphate or triethanolamine. Esters of 2,4,-*D* formed by combining it with ethyl, butyl and methyl alcohols, require oil carriers for efficient distribution. They form emulsions in water.

The formulations in Table 1 utilize the acid powder, which may be obtainable only in large quantities. Solution No. 1 is particularly useful for the eradication of cattails and water lilies. The acid powder of 2,4-*D* is valued at about $1.05 per pound. Tributylphosphate, a liquid, sells for about $0.80 per pound, and triethanolamine, also a liquid, for about $0.75 per pound. These figures may help the reader to judge the true worth of the many weed control products now on the market.

Table 2 may enable the user of 2,4-*D* and closely related products to prepare suitable solutions from commercial products, employing either water or oil.

Weed control procedures are rapidly being modified as new products appear on the market. In fact, combinations of the new agents, such as 2,4-*D* and ammonium sulfamate, are being used more effectively than one agent alone. They will have their greatest utility in the control of terrestrial plants.

Summary

The phenoxyacetic compounds are of little or no value for the control of submersed plants because of the great cost involved.

The hydrocarbons, such as orthodichlorobenzene, trichlorobenzol, dichlorobenzol and naphtha, have been employed in weed control at rates of 20–50 gal. per acre, but these chemicals are highly toxic to fish in the quantities required to destroy submersed plants.

The aniline dye, nigrosine, has been used successfully in Arizona lakes and hatchery fish ponds at Leetown, W.Va., for weed control at rates as low as 10 lb. per surface acre. Experiments have demonstrated that this dye is harmless to fish and other aquatic organisms, and the entomostracan, *Daphnia magna,* has successfully survived rates of application as high as 20 lb. per acre-foot (7.2 ppm.). In fish ponds, weekly applications of 10 lb. of the dye per acre for one month had little effect upon plankton, and bottom animals increased in two out of three ponds studied. It is believed that this dye has potentialities in the control of submersed weeds in impounding reservoirs.

The phenoxyacetic compounds, 2,4-*D* and 2,4,5-*T*, and their salts or esters,

TABLE 2

Preparation of Solutions From Commercial Products

2,4-*D* Acid Content of Herbicide *per cent*	Amount of Herbicide Needed for 100 gal. of Spray Solution (1 per cent) *lb.*
90	8⅓
85	9 5/17
80	10
70	11⅔
60	13⅓
Liquid	***gal.***
40	2½
20	5
10	10

may be employed for the control or eradication of plant growths on the shores and embankments of impounding reservoirs. Some plants, such as water lilies and cattails, have waxy coatings which can best be penetrated with oil formulations. Complete eradication requires successive applications.

Formulations for 2,4-*D* are listed which may be of assistance to superintendents of water supply reservoirs in preparing spray solutions from commercial brands.

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Discussion

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E. W. Surber's paper should be of great help to most water works men, who know very little about aquatic weeds and their extermination. As an illustration of this lack of knowledge, one of the Pennsylvania utilities of the American Water Works Co. has been troubled by this problem for the past twenty years. Until the spring of 1949 none of the herbicides employed had been successful. At that time Borascu * (an unrefined, concentrated borate ore, akin to borax) was tried and proved so effective that the remainder of the reservoir banks are being treated with it this year. The chemical was applied at the rate of 12 lb. per 100 sq.ft. of area. Poison ivy, to take one example, started to die about three weeks after application. Borascu has also been used with success at Summit, N.J., where the dosage applied was 15 lb. per 100 sq.ft.

It should be pointed out that Borascu is a "soil sterilizer"—a nonselective weed killer—which will destroy all vegetation and prevent its regrowth until the boron content of the soil is reduced to a concentration suitable for plant life. Obviously, this material should not be used where selective killing is desired.

Only inconclusive negative results have been experienced by the American Water Works Co. with 2,4-*D*. In a shallow water supply reservoir at Warren, R.I., considerable areas are overgrown with water hyacinth. After one section had been sprayed with an ester of 2,4-*D*, the plants appeared to be stronger and the leaves even greener. This experiment is to be repeated in 1950 with heavier, multiple applications.

* A product of Pacific Coast Borax Co., New York.

Performance of Coal-Tar Enamel on Steel Water Pipe and Penstocks

By Graydon E. Burnett

A paper presented on May 24, 1950, at the Annual Conference, Philadelphia, by Graydon E. Burnett, Head, Paint Lab., Branch of Design & Constr., U.S. Bureau of Reclamation, Denver, Colo.

THE merits of steel pipe, its strength and ductility, its resistance to vibration and shock, its adaptability to fabrication in long sections, its leakproof nature and other favorable characteristics, are well recognized. An unfortunate deterrent to its use in conveying water is that steel is subject to corrosion when exposed to moisture and oxygen. It is true that the rate of corrosion of steel water pipe will vary with different conditions of exposure. There are records of steel pipe in service for over half a century without the benefit of any protective measures. Nevertheless, the fact remains that the efficacy of steel water pipe depends greatly on the effectiveness of the protection accorded it against rusting. Corrosion not only shortens the life of the pipe but reduces its carrying capacity by increasing its roughness. Thus, engineers who are desirous of taking advantage of the favorable characteristics of steel for the fabrication of water pipe must necessarily be deeply concerned with what can be done to prevent corrosion.

This paper will review the record and consider the future of coal-tar enamel, a material that, over the years, has gained a great deal of favor as a protective coating for steel water pipe —so much so, in fact, that ten years ago A.W.W.A. specifications were adopted for it (1). Although much has already been written about coal-tar enamel, it appears that there is room for more to be said. There seems to be a need for the correlation of data on friction coefficients as affected by coal-tar enamel linings. The limitations, as well as the strong points of the material, merit discussion. In the past few years the U.S. Bureau of Reclamation has learned things about coal-tar enamel that are thought to be of interest. The bureau has also made a point of asking others about their experiences and has had a generous response. It seems worthwhile, therefore, to consider the performance of coal-tar enamel in the light of the facts at hand today.

Early History

It must be remembered that coal-tar enamel, as manufactured in modern, plasticized form for the water works industry, is a relatively new product, only fifteen or twenty years old. Yet, basically, it is a compound of coal-tar pitch, which has been used in various forms for many years for the protection of steel. The changes that have been made may be considered improvements, and there is good reason to believe that the modern material will outperform its early counterparts.

Although coal-tar pitch was discovered in 1681 (2), the first known reference to its use as a protective coating

was in an English patent issued to Angus Smith in 1848. It was used as a coating for cast-iron water pipe in the eastern United States as early as 1858 (3), but, apparently, the oldest documented record of its services in the protection of steel was on the steel drydock built in 1892 in North Shields, England (4). When removed from service 46 years later the original coating was reported to be still intact, and maintenance over the years had consisted only of occasional patching to repair abraded spots.

An early example of successful coal-tar enamel application in the United States was its use on the interior of a steel water storage tank owned by the Southern California Edison Co. (4). The tank was coated and placed in service in 1912. When examined 27 years later the coating was still in perfect condition below the water line, although it had sagged and alligatored above the line from the heat of the sun, and some pinholes had required patching. In 1913 the Pacific Gas and Electric Co. applied a test patch of enamel in a penstock, and this was reported as looking like new after 26 years of service (4).

An impressive record for an early form of coal-tar enamel has been made in the penstocks of Gatun Hydroelectric Station in the Canal Zone. Three penstocks 10½ ft. in diameter were enameled in 1912, and an additional three in 1918. A 1950 report indicates very satisfactory performance over the 38-year period. Maintenance had consisted of patching loose or blistered areas during shutdowns for repair of generators.

No doubt there are many other examples of satisfactory applications of coal-tar enamel to steel pipe in the early part of this century. The point to be made is that coal-tar enamel, even in its unimproved early forms, is basically capable of providing effective, long-life protection for steel submerged in water.

Modern Coal-Tar Enamel

It was around 1930 that coal-tar enamel manufacturers achieved a definite improvement in their product. By a variation in processing, the enamel acquired a more plastic or rubbery character. Its sagging point was raised from about 140°F. to 160°F., and the temperature at which it would crack from cold was lowered from 20°F. to − 20°F. or less. This change was effected without impairing the enamel's primary attribute of very low moisture absorption. Tests conducted in the U.S. Bureau of Reclamation laboratories have shown results comparable with those reported by Hayes in 1940 (4). During one year of continuous immersion in tap water, coal-tar enamel of five penetration at 77°F. absorbed 0.5 g. of water per square foot of surface; coal-tar enamel of fourteen penetration and coal-tar pitch of eleven penetration each absorbed 0.3 g. per square foot; three asphaltic materials absorbed from three to ten times as much as the coal-tar materials; and a microcrystalline wax absorbed about the same amount. Although the old product served well in appropriate exposures, the improvements widened considerably its effective range with no decrease in protective capacity.

Striking comparisons of the new and old enamel may be made, based on the bureau's experiences. The old form of enamel cracked and disbonded from the Malheur Siphon, a welded steel pipe of 80-in. diameter located in Oregon, when a minimum temperature of 5°F.

was reached. The new enamel has withstood a −25°F. temperature on exposed and empty portions of penstocks at Estes Park, Colo.

An outstanding, and possibly exceptional, example of the ability of modern coal-tar enamel to resist cold is its performance on an 84-in. steel pipe spanning the Missouri River near Toston, Mont. Installed by the Montana State Water Conservation Board with a spun-enamel coating in 1938, the pipe has been exposed each winter, empty, to temperatures as low as −43°F. Minor damage only, with the bulk of the coating still in excellent condition, is reported in 1950.

Proof of the general effectiveness of the modern coal-tar enamel comes from a wide distribution of users. In 1948 the Bureau of Reclamation made a survey of ten public and private water and power organizations, representing eastern, midwestern and western areas of the United States. Favorable experience with coal-tar enamel on steel water pipe was universal. Records of satisfactory service covered from six to 40 years, and the anticipated life averaged 40 years. Such an estimate from consumer sources must be considered conservative.

The Los Angeles Dept. of Water and Power was one of the first agencies to make extensive use of modern coal-tar enamel. A city-operated coating plant was set up to apply enamel by spinning (5) and large amounts of steel pipe have been lined in this manner. Testimony to the effectiveness of coal-tar enamel was given in 1946 by Hurlbut (6), with particular reference to the Bouquet Canyon Siphon, where no deterioration of the coating was observed in a twelve-year period.

The Metropolitan Water Dist. of Southern California also has had favorable experience with coal-tar enamel on many miles of steel pipe. A typical example is the spun-enamel lining in 10 miles of steel pipe, averaging 11 ft. in diameter, across the Santa Ana River, which has required no repairs in ten years of service (7).

Less than 1 per cent of the hand-daubed enamel in four 60-in. penstocks of the Southern California Edison Co.'s Kern River Borel Power House was found defective after fourteen years of service.

The enamel lining on a 78-in. steel pipe carrying raw sewage, plus waste of all descriptions, across the South Platte River in Denver has shown no sign of deterioration in more than twelve years of continuous service (8).

Most of the Bureau of Reclamation's experience with modern coal-tar enamel has been since World War II. The material was, however, applied to the Hoover Dam penstocks in 1936. Infrequent opportunities have been taken to inspect the coatings when generating units were shut down for repair. Performance has varied in the four different penstock headers. About 30 per cent of the coating in the invert area, or 10 per cent of the total, of the upper Nevada penstock header became disbonded within two years of service, whereas, in the upper Arizona penstock, less than 0.2 per cent of the total coating was found defective after nine years' service. It is significant that the upper Nevada penstock was the first to be coated, and it is known that application techniques were not as good then as later. Shop-spun enamel in the Friant Dam outlet pipes, after eight years' service, and hand-daubed enamel in the Shasta Dam penstocks, after five

years' service, have been found to be in virtually perfect condition. So also was the coal-tar enamel applied as a test coating in one of the Grand Coulee Dam outlet pipes after the six-year test period.

It is apparent that the modern material has an enviable record as a protective coating for the interior surfaces of steel water pipe and penstocks. Evidence is ample to indicate continued good performance for many years. In reviewing the facts today, there seems to be no reason to doubt Hayes' statement (4) made in 1940: "On this evidence, the bureau [Los Angeles Bureau of Water Works and Supply] bases its belief that the improved coal-tar enamel, when properly applied and installed, will give a permanent protection to its steel water lines."

Effect on Capacity

A primary consideration for any protective lining for steel water pipe is its effect on carrying capacity, not only in the initial operation but over the years. Economy in design is, of course, influenced to a great extent by the flow coefficient that can be safely ascribed to the lined pipe.

It was very natural and proper in earlier days to employ conservative coefficients for enamel-lined steel pipe. Little actual test data were available and conservatism was necessary, especially from the standpoint of insuring adequate capacity over an extended period, because the engineer could not be certain of continued performance of the lining. Today the picture has changed. Not only have considerable test data been accumulated to show a low initial roughness factor, but there is ample evidence to justify the expectation that flow capacity will be maintained for a long time.

TABLE 1

Flow Coefficients for Enamel-lined Steel Pipe

Pipe Size *in.*	Location or Owner	Application Method	Length of Service *years*	Hazen-Williams *C*	Kutter *n*
48, 36	El Capitan Pipeline, San Diego, Calif.	spun	1	140	
48	Washington, D.C.	spun	4	145	
51, 123	San Gabriel Dam No. 1, Los Angeles County	spun	3		0.009, 0.010
48	San Luis Rey Siphon, San Diego Aqueduct	spun	2		0.0103
80, 96	Bouquet Siphon, Los Angeles	hand-daubed	1		0.011
31.4	Los Angeles	spun	new	142, 155	
30	Panther Valley Water Co.	spun	1	123.9, 145.8	
30	Panther Valley Water Co.	spun	8	144.9	
26	Los Angeles	spun	new	158	0.0097
60	St. Louis, Mo.	spun	2	140, 142	

Table 1 gives the results of flow tests made on enamel-lined, welded steel pipe by a number of investigators. Some of these data have previously been published (9, 10). For spun enamel linings, the average Hazen-Williams *C* is 143.7, and the average

Kutter n is 0.0097. These uniformly favorable coefficients indicate that a very smooth surface will be obtained with coal-tar enamel, a fact which is not at all surprising to anyone who has looked at the mirrorlike surface of a properly spun enamel lining. It is to be expected that hand-daubed enamel will present a rougher surface; even so, a value for n of 0.011 is indicated for this treatment.

Fifteen years ago a Kutter n of 0.014 was commonly applied to the design of welded steel pipe lined with coal-tar enamel. Before long it became apparent from flow tests and observations of durability that this figure was too high, and most engineers lowered the design value to 0.012 (11). Now a value of 0.011 or a C of 130 is being used by competent engineers. Factual flow test data on linings up to eight years of age, together with each year's added assurance that coal-tar enamel will endure, have shown the way to greater economy in steel water pipe design.

Conditions of Use

Although coal-tar enamel is considered an excellent protective coating for steel water pipe, it must be used appropriately within its limitations. This fact was brought forcibly to the attention of the Bureau of Reclamation by experiences in exposing enameled pipe to very cold temperatures.

The early cold-weather failure of coal-tar enamel in the Malheur Siphon may be discounted as a measure of the ability of the modern enamel to withstand cold, because it was of the older, common-pitch type. Not to be discounted, however, are the several failures that have occurred in shop-applied coatings since the war. The first took place in the winter of 1947–48, when sections of empty, enamel-lined 87-in. pipe were exposed in the mountains to temperatures as low as − 38°F. Even though the enamel was of the processed or plasticized type, conforming with A.W.W.A. specifications for what was then called Type *A*, and was properly applied, most of it was lost by cracking and disbonding. Several similar failures followed in other cold locations, most of them resulting from the application of an enamel that was too hard, even though within specification requirements. Experience has since shown that, by more rigid specification requirements and better control of application procedures, it is possible to obtain coal tar enamel coatings which are much less susceptible to cold (12). As mentioned before, enamel lining on exposed and empty 78-in. pipe has survived two winters at Estes Park, Colo., with temperatures down to − 25°F. In spite of this fact, and with due regard to the favorable experience with the enameled steel pipe span at Toston, Mont., it is not considered a good risk to expose enamel-lined pipe to temperatures under − 20°F.

One limitation of enamel in cold weather which should be remembered is that, although it may withstand a temperature of − 20°F. when the pipe is undisturbed, it can be damaged if handled at much higher temperatures. Much depends on how gently the pipe is handled and upon its rigidity. Thick-plate pipe has been installed on bureau projects in zero weather without cracking the enamel lining. On the other hand, enamel on large-diameter, thin-walled pipe has been damaged at around freezing temperature. Susceptibility to damage in handling is not considered a serious limitation on the use of coal-tar

enamel but is mentioned to invoke precautionary measures where needed.

The high softening point of modern enamel has virtually eliminated sagging of the coating in hot weather. Heat-reflective coatings, to minimize the absorption of heat when enameled pipe is exposed to direct sunlight, are required, however. Those indicated in the A.W.W.A. specifications are suitable.

There is divided opinion on the durability of coal-tar enamel as an exterior coating for buried steel pipe. There are some examples of excellent service. It is reported that the enamel coating on 225 miles of 8¾-in. gas line which was taken up for re-laying had maintained the pipe in perfect condition over a sixteen-year period (13). Coal-tar coated domestic water pipe using a plain burlap wrap is reported to be still in good condition after 35 years' service, even though sections are laid in alkaline soils. The well known American Petroleum Institute–National Bureau of Standards pipe coating tests gave a relatively good rating for shielded coal-tar enamel as an exterior pipe coating (14), although no coating prevented pitting altogether in all soils over the 10-year test period. The wide use of wrapped enamel coatings on oil and gas pipelines is an indication of the confidence placed in the material's ability to mitigate soil corrosion.

One point that has been demonstrated consistently is the need for a good shield to minimize the effects of soil stress on the coating, unless the pipe is laid in a sand screen or in well drained, sandy soils. Also it has been reported that an unwrapped enamel coating is subject to perforation by roots. Some engineers question that the usual asbestos-felt wrap is an adequate shield, especially under severe soil conditions. The bureau has found that an open-structured fibrous-glass wrapping is desirable as integral reinforcement of a multiple-coat system, but it would not appear that this material could function effectively as a shield against soil stress.

It may be significant that cathodic protection is being used widely and with good effect to supplement protective coatings on the exterior of buried steel pipe (15, 16). It is not necessary to install cathodic protection for an entire pipeline during construction. Tests can be made later to locate areas where it is needed. There is good reason to believe that a wrapped coal-tar enamel coating, supplemented by cathodic protection as needed, will provide virtually permanent protection, regardless of soil conditions.

Future of Coal-Tar Enamel

This paper presents a generally favorable record of performance for coal-tar enamel on steel water pipe and penstocks. It is obviously an excellent protective coating embodying good flow characteristics, but, of course, it is not perfect.

Several improvements are needed. One is to impart better resistance to cold. The Bureau of Reclamation has suggested a step in this direction by requiring a softer grade of enamel (minimum penetration of thirteen rather than seven at 77°F.) than has been insured under A.W.W.A. Type *A* specifications.* The bureau also provides against overheating of enamel in

* A revision to the specifications adopted by the A.W.W.A. on June 21, 1950 (see this issue, p. 774), changes the penetration range at this temperature from a minimum of seven and maximum of sixteen to ten and twenty, with values of fifteen to twenty required for cold-weather exposures.—Ed.

the application process by setting a minimum value of seven for penetration of the material as applied. There is evidence that these measures are beneficial (12), but it would be desirable to go further, if this is possible without introducing complications from warm-weather sagging or other undesirable properties.

Another point of concern is the exceptional care required in the application process. The bureau and others have found it necessary to impose a high degree of inspection on enameling work to make certain of satisfactory results. Inspectors need special training in the processes. Although the expense of such inspection is warranted under the circumstances, it would be advantageous if the application procedure could be made less critical. Perhaps more tolerance could be provided in the thickness and drying time of the primer, in enamel heating requirements and in the application temperature range. Although A.W.W.A. specifications indicate that a metal temperature of 45°F. is not too cold for enameling work, it is commonly felt that warmer metal is desirable to insure effective bond, especially if the pipe is fabricated of heavy plate. Heating pipe to obtain warm metal is often difficult and expensive. Most engineers are convinced of the need for blast-cleaning of metal to assure good durability in almost any protective coating for steel pipe, but if enamel coating manufacturers could provide for more latitude in the application of their product, much would be gained.

In the coating plant, enamel is applied with efficiency and dispatch to interior and exterior surfaces of straight pipe sections. This is not true for installed large-diameter pipe or for specials or joints, where the slow and laborious hand-daubing method is used. Whether by hot spray or otherwise, a field application procedure is needed which will introduce greater efficiency in the operation and will result in a smoother coating. Recently some progress in this direction has been made by using glass fiber mops, but these cannot be employed to apply enamel overhead.

These matters are mentioned lest the manufacturer and applier of coal-tar enamel become too complacent about the present product and coating methods. No definite advance in either has been apparent in the last ten years. If coal-tar enamel is to hold its place as a preferred protective coating for steel pipe, the need for progress must not be ignored.

Summary

1. Evidence is presented to show that modern coal-tar enamel, properly used, can effectively mitigate the interior corrosion of steel water pipe for a long period.

2. Factual data indicate that a flow coefficient of 0.011 for Kutter's n or of 130 for the Hazen-Williams C is reasonable for the design of steel pipe lined with coal-tar enamel.

3. Although extreme cold limits the use of coal-tar enamel, much more latitude in this respect can be realized by seeing that the material has the greatest practicable degree of plasticity as applied.

4. A wrapped coal-tar enamel coating, supplemented by cathodic protection as needed, is believed to provide virtually permanent protection to the exterior of buried steel pipe.

5. There is still room for improvement in the product and application

process, especially in minimizing the critical nature of certain phases of current application procedure.

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Further Studies With the Direct Colorimetric Hardness Titration

By J. D. Betz and C. A. Noll

A paper presented on May 22, 1950, at the Annual Conference, Philadelphia, by J. D. Betz, Asst. Gen. Mgr., and C. A. Noll, Chief Chemist, W. H. & L. D. Betz, Philadelphia.

WITHIN the past year the new direct colorimetric hardness titration has met with widespread interest. Almost of equal importance has been the development of a similar direct titration method for the determination of calcium. The superiority of these titrations over the soap hardness method in convenience and rapidity has led to their immediate acceptance. The extreme sensitivity and accuracy of these colorimetric methods have contributed further to the replacement of the soap tests. In fact, the great accuracy that can be achieved has introduced problems not considered when using the soap method, and these new problems are discussed in this paper.

A primary difference between the soap test and the new colorimetric hardness titration is that the former measures the soap-consuming power of a water, whereas the latter measures the total calcium and magnesium present. The soap test not only measures calcium and magnesium but also iron, aluminum and high brine content. Although numerous refinements of the soap test have been made in an attempt to restrict the results to the sum of calcium and magnesium, its very nature makes accuracy uncertain.

The new colorimetric hardness test is based on the determination of the total calcium and magnesium content of a sample by titration with a sequestering agent in the presence of an organic dye sensitive to calcium and magnesium ions. The calcium test is based on the same principle, using as an indicator an organic dye which is sensitive to calcium ions and insensitive to magnesium ions under test conditions. The basic principle of these tests was developed by Schwarzenbach in Switzerland. The authors have presented data on recommended reagents, procedures and the like (1).

In the course of the past year the Betz laboratories have run more than 30,000 colorimetric hardness titrations under the supervision of the authors. Many of these tests were compared directly with the soap hardness method and with gravimetric results. These data are included in a previous paper (1). In the course of conducting these tests on almost every type of water, several additional problems have been encountered, which will be discussed below.

Effect of Filtration

The direct colorimetric titration for hardness is extremely sensitive, and it is possible, by using a 100-ml. sample and a microburet for titration, to obtain an accuracy of 0.1 ppm. hardness.

Experience has shown this method to be so sensitive that caution must be taken in filtering samples prior to analysis, since small amounts of hardness picked up from the filter paper are readily detected by the test.

Table 1 illustrates the results obtained in the filtration of water samples through three grades of filter paper. In one series of tests, distilled water of zero hardness was employed. Tests were also conducted on distilled water to which calcium chloride was added to produce 4.0 ppm. hardness as $CaCO_3$.

TABLE 1

Effect of Filtration on Hardness

Whatman Filter Paper		Filter Paper Not Washed		Filter Paper Washed with Sample	
		Initial Hardness *ppm.* ($CaCO_3$)		Initial Hardness *ppm.* ($CaCO_3$)	
No.	Texture	0.0	4.0	0.0	4.0
		Hardness Found *ppm.* ($CaCO_3$)		Hardness Found *ppm.* ($CaCO_3$)	
2	medium	1.8	5.0	0.5	4.1
4	rapid	1.1	4.5	0.3	4.0
5	close	0.8	4.5	0.4	4.1

In the unwashed-paper tests, 100 ml. of sample was filtered through an initially dry filter paper and, as can be noted from Table 1, an appreciable hardness increase was obtained, particularly on the zero-hardness sample. In the other series of tests, the filter paper was washed by discarding the first 200 ml. of filtrate and taking the third 100 ml. for testing. This washing action reduced the amount of hardness picked up from the filter paper.

Based on these results, it is recommended that the filtration of low-hardness samples be avoided. If filtration is required, however, the paper should be well washed with the sample in order to minimize hardness contamination.

Glass Bottles

It was observed that condensed steam and condensate samples of excellent purity and low specific conductance showed unexpected hardness values by the direct titration method. Investigation revealed that hardness was contributed to the sample by glass sampling bottles. As shown by Table 2, a greater amount of hardness contamination was contributed by soda-lime bottles than by pyrex bottles. The hardness increase was greater when the sample was added to the bottle hot (80°C.) than when added cold (25°C.). In these tests, distilled water of zero hardness was employed, together with distilled water to which calcium chloride was added to produce 4.0 ppm. hardness as $CaCO_3$. As was observed in the filtration test, the hardness increase was greater with the water of zero hardness content.

Table 3 illustrates results secured under the same conditions, except that, prior to testing, 100 ppm. of sodium hydroxide was added to each sample to develop a pH of 11.1.

Boiler Water Hardness

If an adequate soluble-phosphate concentration and pH value are maintained in a boiler water, zero hardness by the soap test can be expected. The more sensitive direct colorimetric titration, however, will indicate a small amount of boiler water hardness even under these conditions. This small amount of hardness, previously unrevealed by the soap method, is not significant from the standpoint of boiler

TABLE 2

Effect of Glass Bottles on Hardness at pH 6.5

Period of Contact hr.	Initial Hardness = 0.0 ppm.				Initial Hardness = 4.0 ppm.			
	Soda-Lime Glass		Pyrex Glass		Soda-Lime Glass		Pyrex Glass	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
	Hardness Increase—*ppm.* ($CaCO_3$)							
2	1.9	0.2	1.5	0.1	1.0	0.0	0.4	0.1
4	1.9	0.2	1.5	0.1	0.9	0.1	0.3	0.0
6	1.8	0.2	1.3	0.1	0.8	0.0	0.5	0.0
8	1.9	0.2	1.4	0.1	0.9	0.0	0.4	0.0
24	2.0	0.2	1.4	0.1	0.8	0.0	0.4	0.0
48	1.9	0.2	1.3	0.1	0.9	0.1	0.4	0.1
120	2.4	0.4	1.8	0.5	1.0	0.0	0.4	0.1

cleanliness and control of internal chemical treatment.

Table 4 illustrates tests conducted on boiler water samples obtained in three types of containers. Samples were analyzed after 48 hours' contact with the container. Although some hardness can be expected from contact with glass, hardness is shown also for the samples secured in plastic and hard-rubber bottles. Gravimetric analyses have revealed that a small amount of hardness actually exists in boiler water even in the presence of adequate phosphate and pH values.

Calcium Chloride Solutions

Data have been presented previously (1) on the accuracy of the direct titration methods for total hardness and

TABLE 3

Effect of Glass Bottles on Hardness at pH 11.1

Period of Contact hr.	Initial Hardness = 0.0 ppm.				Initial Hardness = 4.0 ppm.			
	Soda-Lime Glass		Pyrex Glass		Soda-Lime Glass		Pyrex Glass	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
	Hardness Increase—*ppm.* ($CaCO_3$)							
2	0.9	0.3	0.4	0.3	0.3	0.1	0.0	0.1
4	0.9	0.3	0.3	0.3	0.3	0.1	0.0	0.1
6	0.9	0.3	0.3	0.4	0.2	0.2	0.0	0.1
8	0.9	0.4	0.3	0.4	0.3	0.2	0.0	0.1
24	0.9	0.7	0.3	0.3	0.4	0.6	0.0	0.1
48	1.3	1.1	0.4	0.2	0.4	0.8	0.0	0.1
120	2.0	2.0	0.4	0.4	1.1	1.0	0.0	0.0

calcium in water samples of high hardness. In both methods, hardness values as high as 1,200 ppm. can be determined accurately without dilution of the sample and with the standard-strength titrating solution (1 ml. = 1 mg. $CaCO_3$).

Table 5 gives further data obtained on calcium chloride solutions by the hardness and calcium methods. These data were determined without dilution of the sample, but with a titrating solution of 1 ml. = 10 mg. $CaCO_3$. As can be noted, both methods yield quite accurate results until the endpoint becomes difficult to obtain as a result of the large volume of titrating solution introduced.

TABLE 4

Boiler Water Hardness

Plant	Direct Titration			Soap Method	Boiler Water Analysis			
	Plastic Bottle	Hard-Rubber Bottle	Glass Bottle		Alkalinity—*ppm.* ($CaCO_3$)		pH	PO_4 *ppm.*
	Hardness—*ppm.* ($CaCO_3$)				Phenol-phthalein	Methyl Orange		
A	2.0	2.0	2.0	0	536	660	11.5	50
B	1.6	1.6	2.8	0	192	300	11.3	20
C	0.6	0.6	2.0	0	292	340	11.3	20
D	2.4	2.3	2.4	0	296	340	11.4	25
E	0.8	0.9	2.4	0	372	480	11.4	70

Stability of Reagents

All three solutions stored in unopened bottles have been satisfactory after eight months. In experiments where the titrating solution and the indicator solution were stored in bottles opened at weekly intervals for testing, both solutions were entirely satisfactory after eight months (Table 6).

The buffer solution was found to be stable for only four months when the storage bottle was opened at weekly intervals for testing. Loss of sulfide was experienced as a result of this exposure, and, consequently, the buffer solution no longer eliminated copper and manganese interference. The buffer solution was still perfectly satisfactory for use when copper and manganese were not present in the water to be tested. Confirmation of these results was obtained by opening the buffer solution bottle daily and shaking to aerate. Under these test conditions also, the buffer solution remained satisfactory for four months. Tests on buffer solutions of higher sulfide content are in progress, and these solutions are still satisfactory after four months. It is expected that, by using a higher sodium sulfide content, the stability period of the buffer solution can be considerably extended.

The dry calcium indicator has been found stable over an eight-month period in bottles opened weekly for testing purposes.

In normal use, no special precautions will be required by the stability condition of the titrating solution, hardness indicator or calcium indicator.

For the hardness buffer solution, it is recommended that supplies for more than three months' use be kept in closed bottles and that the container in current use contain no more than a three-month supply.

Miscellaneous Observations

Occasionally a water sample is encountered which, because of a very high copper or manganese content, gives difficulty with the endpoint. It has been found that the addition of a crystal of sodium sulfide to the sample in the casserole will usually eliminate this interference by precipitating the offending metal ion.

In general, it has been found desirable in the routine analysis of boiler water samples to take a 25-ml. sample, dilute it with 25 ml. of distilled water and thus automatically eliminate the effect of possible high hydrate concentrations. By this procedure, any high color value of the boiler water is diluted and observation of the endpoint made easier. Because of the extreme sensitivity of the titration method, such dilution will not significantly affect the test accuracy.

TABLE 5

Titration of Calcium Chloride Solutions*

Calcium Chloride Present	Hardness Found	Calcium Found
	ppm. ($CaCO_3$)	
1,000	1,000	1,000
2,000	2,000	2,000
5,000	5,080	5,080
10,000	10,200	10,200
20,000	20,300†	20,300†

* Titrating solution: 1 ml. = 10 mg. as $CaCO_3$ (pH adjusted to 10.3).
† Endpoint difficult to obtain because of large volume of titrating solution.

In a previous paper (1) the use of a 100-ml. sample and a microburet for titration was recommended to get accuracy within 0.1 ppm. in the low-hardness range. A 1.0-ml. quantity of buffer solution is used, and seven to nine drops of hardness indicator solution were recommended. Further studies have indicated that greater clarity of the endpoint in the low-hardness range can be secured by restricting the indicator to three or four drops.

The high degree of accuracy possible with the direct titration method for hardness is very useful in the control of lime-soda softeners, hot-phosphate softeners and the various ion-exchange processes. In selective calcium softening, the direct titration method for calcium is also quite useful.

Many high-pressure power plants have installed recording conductivity equipment on the turbine condensate from the condensers. Such recorders are of great value in detecting condenser leakage and consequent undesirable contamination of the boiler feed-

TABLE 6

*Stability of Reagents**

Reagent	Test Conditions†	Results
Titrating solution	*A*	satisfactory after 8 mo.
Hardness indicator solution	*A*	satisfactory after 8 mo.
Hardness buffer solution	*A* & *B*	stable for 4 mo. only‡
Calcium indicator	*A*	satisfactory after 8 mo.

* All reagents stored unopened were satisfactory after 8 mo.
† Test conditions: *A*—bottle opened at weekly intervals for testing; *B*—bottle opened daily and shaken to aerate. tests conducted weekly.
‡ Buffer solution with increased sodium sulfide content was stable for longer period; tests are still in progress.

water. Sometimes, because of slight variations in the ionizable gases present in the steam from the boilers or slight variations in the solids content of the steam, it is not possible to determine immediately if an indicated higher conductivity value is due to these causes or to condenser leakage. Using the procedure for low hardness on a condensate sample will aid in determining whether condenser leakage exists, since hardness is thus introduced into the condensate and is readily detected by the low-hardness procedure.

Conclusions

Further studies with the direct colorimetric titration have revealed the necessity for certain precautions in interpreting the hardness values obtained, since the sensitivity of the hardness titration detects contaminating influences not shown by the soap hardness test. Caution must be used in filtering samples prior to analysis and in interpreting the small quantity of hardness contributed by glass bottles. The small amount of boiler water hardness detected by this test is not significant from a treatment standpoint.

It has been shown that the titrating solution, hardness indicator and calcium indicator are quite stable. Some precautions must be exercised when using opened bottles of the buffer solution.

Within a relatively short period the direct titration methods for hardness and calcium have met with widespread acceptance that is well justified by their convenience, rapidity and accuracy.

Reference

1. Betz, J. D. & Noll, C. A. Total Hardness Determination by Direct Colorimetric Titration. Jour. A.W.W.A., **42**: 49 (Jan. 1950).

Basic Water Use Doctrines and State Water Control Agencies

Committee Report

A committee report presented on May 24, 1950, at the Annual Conference, Philadelphia, by Richard Hazen, Chairman. The other members of the (temporary) committee were: O. J. Muegge, D. A. Okun, L. W. Trager, D. S. Wallace and W. W. Wheeler.

ANYONE familiar with water control law in the United States will recognize that a compilation of such legislation would require a great many volumes if it were to be complete and correct. Such a work might be useful to lawyers, but, since it would almost certainly be out of date in some respects as soon as it was completed, it is doubtful if the benefits would be worth the time and energy required to put it together. Consequently, in this report, the committee has confined itself to presenting a summary of the basic use doctrines and to noting for each state what agencies perform the several functions pertaining to water resources control. The latter information may be found in the tabulated material at the end of the report (pp. 762–73).

The committee has tried to answer in general such questions as: what is the basic underlying water law for both surface and ground water developments? what state agencies must approve water uses? are stream pollution laws in effect? what agency administers them? In many of the states, the functions of the several agencies are not clearly defined, and there is some overlapping. In others, it is difficult to determine from the law exactly what policies are followed. The tabulation probably includes some errors, and the committee requests that these be brought to its attention.

The work of the committee has been aided considerably by the fact that three of its members have been engaged for several months on a nationwide water resources investigation which has made it necessary to obtain similar data for more than half of the 48 states. The committee would like to acknowledge the prompt assistance that has been rendered by the many state sanitary engineers, representatives of state geological surveys and federal agencies, and others interested in water resources matters.

Basic Water Laws

It is not necessary to discuss in any great detail the various water doctrines. Like most laws, the developments down through the years have been molded by economic necessity. Early laws have had to be changed to meet present-day requirements, and the actual meaning of many laws is defined only by decisions in the courts. For example, Superior Judge E. V. Kuykendall of the State of Washington

pointed out in 1928 that: "The doctrine that a riparian owner was entitled to have the stream flow by his door unvexed and undiminished even though he made no use of the water except to observe its beauty and listen to its babble has been badly shattered by the materialistic courts of the far west. Even our own Supreme Court, sordid and unpoetical as such a doctrine may seem, has adopted the view in late decisions that water is better employed growing onions and alfalfa than by reflecting the beauty of the moon while singing its way unvexed to the sea" (1).

At the risk of considerable oversimplification, the basic water laws applicable to surface water use may be summarized substantially as follows:

Surface Water

1. The *riparian doctrine* (which derives from the common law) accords to each owner of land contiguous to a stream the right to make whatever use of the water he requires for domestic purposes and the watering of livestock, and to make such use of the water for irrigation or other purposes (such as manufacturing) as is reasonable with regard to like reasonable uses by all other owners of land riparian to the same streams.

2. The *appropriation doctrine* (generally provided for by statute) gives to the first user of water from a stream the right to continue his use so long as it is beneficial, and to use the entire supply if it is all necessary to satisfy the right which he has established by beneficial use; whatever surplus may exist at any time being available for later appropriators, in the order of their priorities according to the time of making their appropriations.

In some of the western states, the two doctrines exist concurrently.

Ground Water

For ground waters, there are three primary doctrines of ownership and use:

1. The English or *common law rule* of absolute ownership, which recognizes ownership of subsurface waters by the owner of overlying land and places no restriction upon the landowner's right of use of the water on his overlying land or elsewhere.

2. The American *rule of reasonable use,* which also recognizes ownership of subsurface water by the owner of overlying land but limits his right of use of the water to such use, on or in connection with his overlying land, as is reasonable with regard to the similar rights of all other owners of lands which overlie the same source of water supply.

3. The *doctrine of appropriation,* which adapts to subsurface waters the appropriative principles developed in connection with surface watercourses. This doctrine recognizes ownership of the underground waters by the public, subject to appropriation for beneficial use, and the place of use need not be on lands which overlie the source of ground water supply.

In most of the western states, a distinction is made between percolating waters and ground waters which flow in well defined subterranean watercourses. Waters which flow in definite underground streams are generally subject to the same rules of law as waters in surface watercourses. Separate ground water doctrines then apply only to percolating waters.

The riparian and common law doctrines are generally followed in the

eastern part of the United States, while the appropriation doctrine is used almost exclusively in the western states. For that reason, in arranging the tabular material, the 31 states east of the ninety-seventh meridian have been placed in one alphabetical group and the 17 western states, in another.

It should be noted that, in England, where the common law originated, the rule of reasonable use has been substituted to some extent by statute.

State Authorities

The functions of the various state water control agencies and authorities have been divided into eight categories:

1. *Surface water.* This category pertains to the development and use of rivers, lakes, ponds and the like for purposes such as public water supplies, irrigation, hydroelectric plants or industrial uses, but does not include individual domestic supplies. In most states, developments in existence when the authority was established have the right to continue their water use without recourse to the authority. Hence, the authority applies generally to *new* or *additional* water uses. The jurisdiction of public utility or public service commissions over water rates, water service and other related matters is not included.

2. *Ground water.* This category pertains to the development and use of ground water for purposes such as public water supplies, irrigation or industrial uses, but does not include individual domestic supplies. In most states, developments in existence when the authority was established have the right to continue their water use without recourse to the authority. Hence, the authority applies generally to *new* or *additional* water uses. These agencies are generally concerned with the "taking of ground water" rather than with the details of well construction and sanitary precautions, which are referred to the health departments; in some states, the latter aspects are also covered by the water authority. As for surface waters, the jurisdiction of public utility commissions over water rates and the like is not included.

3. *Dams, diversion works, etc.* This category pertains to the effects of reservoir construction on activities such as: [1] protection of life and property from unsafe structures or inadequate spillways, and from interference with normal drainage; [2] provision for fish and game, particularly the inclusion of fishways or fish ladders on streams used for spawning; and [3] prevention of flood-induced health hazards and nuisances, such as the creation of water surfaces which might encourage mosquito breeding. Not included is the jurisdiction frequently exercised by health departments over the general adequacy of dams and reservoirs as integral parts of public water supply systems, as distinguished from structural soundness.

4. *Water quality and treatment—public supplies.* This category pertains to the jurisdiction normally exercised by state health departments over the design, construction and operation of public water supply systems and over the quality of the water supply, in order to safeguard the health of the people.

5. *Water quality and treatment—industrial drinking water.* This category pertains to the jurisdiction over private water supplies which are provided for drinking and sanitary purposes in industrial plants. Water used for processing only is not included.

6. *Stream pollution control.* This category pertains to policy and control matters, such as the establishment of stream standards and the minimum degree of treatment, as distinguished from routine approval of design, construction and operation of sewage and waste disposal systems. The latter is frequently under the jurisdiction of the health department, acting either separately or as the technical arm of the stream pollution control agency. In many states, the delineation of functions and authority is not rigid and there is some overlapping.

7. *Sewage disposal—technical.* This category pertains to the agency charged with the review or approval of plans, construction and operation of sewerage systems and treatment works.

8. *Industrial waste disposal—technical.* This category pertains to the agency charged with the review or approval of plans, construction and operation of industrial waste disposal systems and treatment works.

In most states, public water supplies are under the jurisdiction of the health department, which has, directly or indirectly, considerable authority over the whole range of water supply development. For example, it is frequently necessary to obtain approval from the health department for the construction of reservoirs, pumping stations and other water supply facilities which are perhaps not directly related to health aspects. The committee has not attempted to indicate this overall jurisdiction except where the health department is the only or principal agency having control.

The committee has distinguished between stream pollution control in general and the technical control of sewage disposal and of industrial waste disposal. Often this distinction is not real, and full authority is vested in the health department or one other agency. There is a growing tendency throughout the country, however, and particularly in the eastern states, toward the creation of water pollution control agencies. These agencies or boards usually include representatives not only of the health department but also of the conservation, recreation and industrial interests. This is an important development, because it reflects the recognition that stream pollution abatement is an economic problem fully as much as it is a health problem. Therefore, the committee has thought it worth while to include in a separate classification the water pollution control boards, where they exist.

In some states, the jurisdiction that applies to a public water supply does not apply to private developments such as might be required for an industrial plant. In the tabulation, the committee has noted this distinction wherever it exists. The development of water supplies for major industrial plants is of increasing importance, and, all too often, the legal complications have been overlooked until other commitments have been made. Health department control in industrial plants usually pertains only to drinking water and waste discharge, and does not concern itself with process water needs.

The tabulation lists the state agencies and authorities under the eight regulatory functions previously mentioned. The titles of the agencies are sometimes misleading, and, as has been noted, their functions occasionally overlap. In general, only those agencies with legal authority are included. Where research and fact-finding agencies have become important in water

supply development, they have also been included, as have agencies with advisory functions where no authority exists. Advisory or research agencies, without authority to compel compliance, are so noted in the listing. The report does not include all the public or semipublic organizations which furnish valuable information on water resources, water quality, existing developments and so forth.

Nearly always, the actions, decisions and orders of the several authorities are subject to appeal in the state courts, and enforcement of the statutes and regulations is obtained through the courts.

Statistical Information

The tabulation of the state agencies has produced some statistics which may be of interest. Of the 48 states, 29 have agencies that exercise some control over the use of surface water. All of the 17 western states have such control authorities, usually acting through the state engineer. There are 13 states with no control agency, while the remaining 6 have agencies with advisory powers. One state has controls that apply to industrial water use only; another, to municipal water use only.

State regulation of ground water use is not so highly developed: 26 states have some agency with authority over ground water use; 18 have no such authority; and 4 have advisory agencies. In one state, control applies to industrial use only; and, in New York State, the control extends to Long Island only.

All of the states have statutes forbidding nuisances or actions affecting the public health. Of the 48 states, 43 have definite laws for controlling stream pollution. In about half of the states, this control is exercised by the state health department, with the conservation department having control over fish and game. Twenty-three states have distinct overall water pollution control bodies to determine policies and set standards. Of these 23 states, 20 are east of the ninety-seventh meridian.

Interstate Activities

One of the interesting developments in recent years has been the rapid growth of interstate compacts and agreements for the control and development of water resources. Under the U.S. Constitution, compacts between states must be ratified by each of the states and consented to by Congress. In addition, there have been several interstate agreements which pertain primarily to water pollution control but do not have the same legal force as a compact. (A list of these compacts and agreements, showing the member states, appears on p. 761.)

In the western states, the water compacts are concerned with the division of available water for irrigation and other water supply purposes. In the eastern states, the compacts have dealt principally with water pollution and the establishment of standards and abatement procedures. The present Incodel (Interstate Commission on the Delaware River Basin) water supply investigation is an exception. The earliest of the water compacts is the Colorado River Compact of 1921, which was approved by Congress in 1928 and ratified by the last member state in 1944. The earliest pollution control compact was the Tri-State Pollution Compact between Connecticut, New Jersey and New York, which was

approved by Congress in 1935 and ratified finally by Connecticut in 1941. Frequently the interstate arrangements have become so important that what can be done within a certain state depends principally upon its interstate commitments. The various interstate water resources commissions, compacts and agreements to which each state is a party are indicated in the state-by-state tabulation.

Thirty-three states are parties to one or more compacts or agreements. Colorado has signed eight compacts and one agreement. Among the eastern states, New York leads the way with membership in four compacts, and it has also signed one agreement. New York has even made the grade as one of the New England states through membership in the New England Interstate Water Pollution Control Commission.

In addition, mention should be made of the Federal Water Pollution Control Act of 1948 for the control of pollution of interstate waters. A special Water Policy Resources Commission has been established recently by the President to make recommendations on federal participation in water resources matters.

Conclusion

The committee wishes to make it clear that this report is in no way conclusive. There are in the committee's files more detailed data concerning the statutes and regulations in the various states. The committee has simply tried to put together in a comparatively short time information that should be helpful to people who are interested in the legal aspects of water resources control. Water law has been a popular subject at recent A.W.W.A. meetings. The committee is not certain exactly how far or in what direction the Water Resources Division of A.W.W.A. might want to go in connection with water law problems, but the committee is convinced that it is a fertile field worth investigating.

The allocation of water has been a critical problem in the western states for a great many years, and the water works men in that part of the country are well versed in the legal aspects of the problem. In the eastern states, up until now, water has been so plentiful that comparatively little attention has been paid to water law except in a few important interstate cases, and with regard to stream pollution. There is still a lot of water in the eastern states, but, unfortunately, much of it is too far away from the centers of population and industry to be of great use. The growing public appreciation of the water supply problem in many parts of the country is obvious. It seems certain that the A.W.W.A. will want to take the lead in fostering the development of policies and procedures to assure an equitable and economical development of the nation's water resources.

Reference

1. Washington Dept. of Conservation & Development. 14th Biennial Rept., Oct. 1, 1946–Sept. 30, 1948. Olympia, Wash., p. 170.

Interstate Commissions, Compacts and Agreements

Congress-approved Commissions and Compacts		Informal Agreements and Agencies	
Name	Participating States	Name	Participating States
1. Tri-State Pollution Compact (Interstate Sanitation Com.)	Conn., N.J., N.Y.	16. Great Lakes Drainage Basin Sanitation Agreement	Ill., Ind., Mich., Minn., N.Y., Ohio, Pa., Wis.
2. Interstate Com. on the Delaware R. Basin	Del., N.J., N.Y., Pa.	17. Upper Mississippi R. Drainage Basin Sanitation Agreement	Ill., Ind., Iowa, Minn., Mo., Wis.
3. New England Interstate Water Poln. Control Com.	Conn., Mass., N.Y., R.I.	18. Missouri R. Basin Health Council	Colo., Iowa, Kan., Minn., Mo., Mont., Neb., S.D., Wyo.
4. Interstate Com. on the Potomac R. Basin	Dist. of Columbia, Md., Pa., Va., W.Va.	19. Red R. Basin Sanitation Agreement (Interstate Sanitation Committee)	Minn., N.D., S.D.
5. Ohio R. Valley Water Sanitation Com.	Ill., Ind., Ky., N.Y., Ohio, Pa., Va., W.Va.*		
6. Red R. Flood Control Compact (Tri-State Water Com.)	Minn., N.D., S.D.		
7. Belle Fourche R. Compact	S.D., Wyo.		
8. Arkansas R. Compact	Colo., Kan.		
9. South Platte R. Compact	Colo., Neb.		
10. Republican R. Compact	Colo., Kan., Neb.		
11. Pecos R. Compact	N.M., Tex.		
12. Rio Grande Compact	Colo., N.M., Tex.		
13. Costilla Creek Compact & La Plata R. Compact	Colo., N.M.		
14. Upper Colorado R. Basin Compact	Ariz., Colo., N.M., Utah, Wyo.		
15. Colorado R. Compact	Ariz., Calif., Colo., Nev., N.M., Utah, Wyo.		

* West Virginia's participation in this commission ruled unconstitutional by state supreme court, April 4, 1950.

Summary of Basic Water Use Doctrines

State	Basic Law		State Authorities			
	Surface Water	Ground Water	Surface Water	Ground Water	Dams, Diversion Works, etc.	Quality & Treatment—Public Supplies
1. Alabama	riparian doctrine	common law	none	none	Secy. of State; Public Service Com.[1]	Dept. of Public Health
2. Arkansas	riparian doctrine	common law	Resources & Development Com. (advisory)[1]	Resources & Development Com. (advisory)	Game & Fish Com. (fishways)	Board of Health
3. Connecticut	riparian doctrine	common law	Dept. of Health[1]	none	Board of Supervision of Dams	Dept. of Health
4. Delaware	riparian doctrine	common law	none	none	none	Board of Health
5. Florida	riparian doctrine	common law	Trustees of Internal Improvement Fund[1]; Board of Conservation	Board of Conservation[1]	Board of Conservation[1]	Board of Health
6. Georgia	riparian doctrine	common law	none	none[1]	Game & Fish Com. (fishways)	Dept. of Public Health
7. Illinois	riparian doctrine	common law	none[1]	Dept. of Mines & Minerals (submission of well logs)[2]	Dept. of Public Works & Buildings	Dept. of Public Health
8. Indiana	riparian doctrine	common law[1]	none	Dept. of Conservation	Flood Control & Water Resources Com.	Board of Health
9. Iowa	riparian doctrine	common law	Natural Resources Council	Natural Resources Council	Natural Resources Council	Dept. of Health
10. Kentucky	riparian doctrine	common law	Dept. of Conservation (advisory)	Dept. of Conservation (advisory)	none	Dept. of Health

and State Water Control Agencies

State	State Authorities (*contd.*)				Interstate Activities*	Notes
	Quality & Treatment—Industrial Drinking Water	Stream Poln. Control	Sewage Disposal—Technical	Industrial Wastes—Technical		
1	Dept. of Public Health	Water Improvement Advisory Com.	Water Improvement Advisory Com.; Dept. of Public Health	Water Improvement Advisory Com.; Dept. of Public Health	none	[1] power and industrial use only
2	Board of Health	Water Poln. Control Com. in Board of Health	Water Poln. Control Com. in Board of Health	Water Poln. Control Com. in Board of Health[2]	none	[1] Game & Fish Com. prevents lowering of stage of river which might affect fish life [2] Oil & Gas Com. regulates disposal of wastes in subsurface formations
3	Dept. of Health	Water Com.	Dept. of Health	Dept. of Health	1, 3	[1] advises General Assembly in granting charters
4	Board of Health	Water Poln. Com.[1]	Water Poln. Com.[1]	Water Poln. Com.[1]	2	[1] Board of Health is administrative agent
5	Board of Health	Board of Health	Board of Health	Board of Health	none	[1] Div. of Water Survey & Research is advisory agency
6	Dept. of Public Health	none[2]	Dept. of Public Health	Dept. of Public Health	none	[1] local control in some areas [2] riparian doctrine only
7	Dept. of Public Health (only when part of public supply)	Sanitary Water Board	Sanitary Water Board	Sanitary Water Board	5, 16, 17	[1] Water Resources & Flood Control Board is coordinating agency [2] Water Survey Div. provides research and technical services
8	Board of Health	Stream Poln. Control Board[2]	Board of Health	Board of Health	5, 16, 17	[1] with some restrictions on use [2] technical assistance by Board of Health
9	Bureau of Labor[1]	Dept. of Health; Conservation Com.	Dept. of Health	Dept. of Health	17, 18	[1] Dept. of Health advises on industrial hygiene
10	Dept. of Health	Water Poln. Control Com.[1]	Water Poln. Control Com.[1]	Water Poln. Control Com.[1]	5	[1] effective June 17, 1950; technical assistance furnished by Dept. of Health and other state agencies

* The numerals in this column indicate membership in the correspondingly numbered interstate compacts, agreements and agencies listed on p. 761.

Summary of Basic Water Use Doctrines

State	Basic Law		State Authorities			
	Surface Water	Ground Water	Surface Water	Ground Water	Dams, Diversion Works, etc.	Quality & Treatment—Public Supplies
11. Louisiana	riparian doctrine[1]	common law[1]	none	none	Dept. of Public Works; Dept. of Wild Life & Fisheries	Dept. of Health
12. Maine	riparian doctrine	common law	Water Resources Div. of Public Utilities Com.	none	Public Utilities Com.	Dept. of Health & Welfare
13. Maryland	riparian doctrine[1]	common law[1]	Dept. of Geology, Mines & Water Resources (except munic. supplies)	Dept. of Geology, Mines & Water Resources (except munic. supplies)	Dept. of Geology, Mines & Water Resources (except munic. supplies)	Board of Health
14. Massachusetts	riparian doctrine[1]	common law	county commissioners	none	county commissioners	Dept. of Public Health
15. Michigan	riparian doctrine	common law	Water Resources Com.	Water Resources Com.; Dept. of Conservation (advisory)	county boards of supervisors	Dept. of Health
16. Minnesota	appropriation doctrine[1]	appropriation doctrine[1]	Dept. of Conservation	Dept. of Conservation	Dept. of Conservation	Dept. of Health
17. Mississippi	riparian doctrine	common law	none	none	none	Board of Health
18. Missouri	riparian doctrine	common law	Div. of Geological Survey & Water Resources (advisory)[1]	Div. of Geological Survey & Water Resources (advisory)[1]	Conservation Com. (fishways)	Div. of Health of Dept. of Public Health & Welfare

and State Water Control Agencies—(contd.)

State	State Authorities (*contd.*)				Interstate Activities*	Notes
	Quality & Treatment—Industrial Drinking Water	Stream Poln. Control	Sewage Disposal—Technical	Industrial Wastes—Technical		
11	Dept. of Health	Stream Control Com.[2]	Dept. of Health	Stream Control Com.; Dept. of Health	none	[1] these concepts provided for in civil code [2] administrative agency is Dept. of Wild Life & Fisheries
12	Dept. of Health & Welfare	Sanitary Water Board[1]	Dept. of Health & Welfare	Sanitary Water Board	none	[1] Dept. of Health & Welfare and Public Utilities Com. have concurrent jurisdiction over certain phases
13	Board of Health	Water Poln. Control Com.	Water Poln. Control Com.; Board of Health	Water Poln. Control Com.; Board of Health	4	[1] diversion of waters for purposes other than munic., domestic or farm use controlled by Dept. of Geology, Mines & Water Resources
14	Dept. of Public Health	Dept. of Public Health; Dept. of Conservation (protection of aquatic life)	Dept. of Public Health	Dept. of Public Health[2]	3	[1] legislature has enacted laws controlling specific supplies [2] Dept. of Public Safety has power over discharge of oil into waterways
15	Dept. of Health	Water Resources Com.	Dept. of Health[1]	Dept. of Health[1]	16	[1] notice of any new disposal of waste must be given to Water Resources Com., which sets minimum restrictions on treatment
16	Dept. of Health	Water Poln. Control Com.[2]	Water Poln. Control Com.[2]	Water Poln. Control Com.[2]	6, 16–19	[1] does not apply to beneficial uses and rights in existence on July 1, 1937, nor to use for any purpose originating within a municipality or for less than 25 persons [2] Dept. of Health is administrative and technical agency
17	Board of Health	Fish & Game Com.	Board of Health	Fish & Game Com.	none	
18	Div. of Health of Dept. of Public Health & Welfare	Div. of Health (health aspects); Conservation Com. (fish life)	Div. of Health	Div. of Health	17, 18	[1] Div. of Research and Development also advisory

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Summary of Basic Water Use Doctrines

State	Basic Law		State Authorities			
	Surface Water	Ground Water	Surface Water	Ground Water	Dams, Diversion Works, etc.	Quality & Treatment—Public Supplies
19. New Hampshire	riparian doctrine	common law	Water Resources Board; legislative charters	none	Water Resources Board	Dept. of Health
20. New Jersey	riparian doctrine[1]	common law[2]	Div. of Water Policy & Supply of Dept. of Conservation and Economic Development	Div. of Water Policy & Supply of Dept. of Conservation and Economic Development	Div. of Water Policy & Supply of Dept. of Conservation and Economic Development	Dept. of Health
21. New York	riparian doctrine	common law and reasonable use rule[1]	Water Power & Control Com.	Water Power & Control Com.[1]	Dept. of Public Works	Dept. of Health (except New York City)
22. North Carolina	riparian doctrine	reasonable use rule	Dept. of Conservation & Development (advisory)	none	Advisory Committee on Hydroelectric Development & Flood Control (advisory)	Board of Health
23. Ohio	riparian doctrine	common law	Div. of Water of Dept. of Natural Resources[1]	Div. of Water of Dept. of Natural Resources[1]	Div. of Water of Dept. of Natural Resources (for industrial supplies only)	Dept. of Health
24. Pennsylvania	riparian doctrine	common law	Water & Power Resources Board (public water supplies only)	none	Water & Power Resources Board	Dept. of Health
25. Rhode Island	riparian doctrine	common law	none	none	Div. of Rivers & Harbors of Dept. of Public Works	Dept. of Health
26. South Carolina	riparian doctrine	common law	none	none	Board of Health; Game & Fish Dept. (fishways)	Board of Health

and State Water Control Agencies—(contd.)

State	State Authorities (*contd.*)				Interstate Activities*	Notes
	Quality & Treatment—Industrial Drinking Water	Stream Poln. Control	Sewage Disposal—Technical	Industrial Wastes—Technical		
19	Dept. of Health	Water Poln. Com.[1]	Water Poln. Com.[1]	Water Poln. Com.[1]	none	[1] Dept. of Health is administrative agency
20	Dept. of Health	Dept. of Health	Dept. of Health	Dept. of Health	1, 2	[1] except that state controls municipal water supplies [2] in certain areas, state controls withdrawals in excess of 100,000 gpd.
21	Dept. of Health (except New York City)	Water Poln. Control Board[2]	Water Poln. Control Board; Depts. of Health & Conservation (up to 1960)	Water Poln. Control Board; Depts. of Health & Conservation (up to 1960)	1–3, 5, 16	[1] controls apply only to public supplies, except on Long Island, where all supplies are controlled [2] New York City has jurisdiction over its watersheds
22	Board of Health[1]	no poln. control law[2]	Board of Health	Board of Health (advisory); Stream Sanitation Com. (advisory)	none	[1] only where supply serves more than 10 residential users [2] Stream Sanitation Com. authorized to make study of pollution
23	Dept. of Health	Dept. of Health	Dept. of Health	Dept. of Health	5, 16	[1] fact-finding and research only
24	Dept. of Health	Sanitary Water Board in Dept. of Health	Sanitary Water Board in Dept. of Health	Sanitary Water Board in Dept. of Health	2, 4, 5, 16	
25	Dept. of Health (advisory)[1]	Dept. of Health	Dept. of Health	Dept. of Health	3	[1] Dept. of Health inspects such supplies; Dept. of Labor has legal authority to require safe drinking water
26	Board of Health	none[1]	Board of Health	Board of Health	none	[1] no stream pollution control law other than for prevention of discharge of wastes prejudicial to public water supplies

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Summary of Basic Water Use Doctrines

State	Basic Law		State Authorities			
	Surface Water	Ground Water	Surface Water	Ground Water	Dams, Diversion Works, etc.	Quality & Treatment—Public Supplies
27. Tennessee	riparian doctrine	common law	none	none	Circuit court of county[1]; Dept. of Public Health	Dept. of Public Health
28. Vermont	riparian doctrine	common law	Com. of Water Resources (advisory)	none	Water Conservation Board	Board of Public Health
29. Virginia	riparian doctrine	common law	none	Geological Survey (to be notified)	circuit courts; Corporation Com. (Hydroelectric power)	Dept. of Health
30. West Virginia	riparian doctrine	common law	none	none	Public Service Com.	Health Dept.
31. Wisconsin	riparian doctrine	common law[1]	Public Service Com.	Board of Health[1]	Public Service Com.	Board of Health
32. Arizona	appropriation doctrine	reasonable use rule[1]	State Water Comr.; Water Div., State Land Dept.	State Water Comr.; Water Div., State Land Dept.	State Water Comr.; Water Div., State Land Dept.[3]	Dept. of Health
33. California	riparian and appropriation doctrines[1]	reasonable use rule	Div. of Water Resources of Dept. of Public Works	Div. of Water Resources of Dept. of Public Works	Div. of Water Resources of Dept. of Public Works	Dept. of Public Health
34. Colorado	appropriation doctrine	appropriation doctrine	State Engineer; Water Conservation Board (advisory)	State Engineer; Water Conservation Board (advisory)	State Engineer; Water Conservation Board (advisory)	Dept. of Public Health

and State Water Control Agencies—(contd.)

State	State Authorities (contd.)				Interstate Activities*	Notes
	Quality & Treatment—Industrial Drinking Water	Stream Poln. Control	Sewage Disposal—Technical	Industrial Wastes—Technical		
27	Dept. of Public Health	Stream Poln. Control Board[2]	Stream Poln. Control Board[2, 3]	Stream Poln. Control Board[2]	none	[1] also Tenn. Valley Authority [2] Dept. of Public Health gives technical aid [3] power to issue orders on sewage disposal curtailed until 1951
28	Board of Public Health	Water Conservation Board	Water Conservation Board	Water Conservation Board	none	
29	Dept. of Health	Water Control Board	Dept. of Health[1]	Water Control Board	4, 5	[1] Water Control Board issues certificate after approval by Dept. of Health
30	Health Dept.	Water Com.	Health Dept.	Health Dept.; Water Com.	4, 5[1]	[1] participation in this commission ruled unconstitutional by state supreme court, April 4, 1950
31	Board of Health	Committee on Water Poln., with Board of Health[2]	Board of Health	Committee on Water Poln., with Board of Health[2]	16, 17	[1] Board of Health controls use of ground water to prevent impairment of public utility wells [2] Board of Health serves as administrative agency
32	Dept. of Health	Dept. of Health[2]	Dept. of Health[2]	Dept. of Health[2]	14, 15	[1] appropriation doctrine for subsurface streams [2] dams more than 10 ft. high or 50-acre-ft. capacity [3] Game & Fish Com. can file suit to prevent pollution that would injure fish or wildlife
33	none	Water Poln. Control Board; Dept. of Public Health (public health hazards only)	Water Poln. Control Board; Dept. of Public Health (public health hazards only)	Water Poln. Control Board; Dept. of Public Health (public health hazards only)	15	[1] riparian right is superior to appropriation right, except that riparian right shall not extend to unreasonable use; other conditions may also subordinate riparian right
34	Dept. of Public Health	Dept. of Public Health	Dept. of Public Health	Dept. of Public Health	8–10, 12–15, 18	

* The numerals in this column indicate membership in the correspondingly numbered interstate compacts, agreements and agencies listed on p. 761.

Summary of Basic Water Use Doctrines

State	Basic Law		State Authorities			
	Surface Water	Ground Water	Surface Water	Ground Water	Dams, Diversion Works, etc.	Quality & Treatment—Public Supplies
35. Idaho	appropriation doctrine	appropriation doctrine	Dept. of Reclamation	Dept. of Reclamation	Dept. of Reclamation[1]	Dept. of Public Health
36. Kansas	appropriation doctrine	appropriation doctrine	Chief Engr., Div. of Water Resources of Board of Agriculture	Chief Engr., Div. of Water Resources of Board of Agriculture	Chief Engr., Div. of Water Resources of Board of Agriculture	Board of Health
37. Montana	appropriation doc-	common law[1]	State Engr.; Water Conservation Board	State Engr.; Water Conservation Board	Board of County Commissioners[2]	Board of Health
38. Nebraska	appropriation doctrine[1]	appropriation doctrine[1]; reasonable use rule	Dept. of Roads & Irrigation	Dept. of Roads & Irrigation	Dept. of Roads & Irrigation	Dept. of Health
39. Nevada	appropriation doctrine	appropriation doctrine [1]	State Engr.	State Engr.	State Engr.	Dept. of Health
40. New Mexico	appropriation doctrine	appropriation doctrine	State Engr.	State Engr.	State Engr.	Board of Health
41. North Dakota	riparian and appropriation doctrines	appropriation doctrine[1]	State Engr.; Water Conservation Com.	State Geologist	Water Conservation Com.[2]	Dept. of Health
42. Oklahoma	riparian and appropriation doctrines	reasonable use rule	Planning & Resources Board	Planning & Resources Board	Planning & Resources Board[1]	Dept. of Health

and State Water Control Agencies—(contd.)

State	State Authorities (*contd.*)				Interstate Activities*	Notes
	Quality & Treatment—Industrial Drinking Water	Stream Poln. Control	Sewage Disposal—Technical	Industrial Wastes—Technical		
35	Dept. of Public Health	Dept. of Public Health (advisory)[2]	Dept. of Public Health (advisory)[2]	Dept. of Public Health (advisory)[2]	none	[1] for dams more than 10 ft. high or 100-acre-ft. capacity [2] no antipollution law
36	none	Board of Health	Board of Health	Board of Health	8, 10, 18	
37	Board of Health	Board of Health	Board of Health	Board of Health	18	[1] except for ground waters flowing in defined underground streams [2] acts only upon complaint that dam is insecurely built
38	Dept. of Health	Dept. of Health[2]	Dept. of Health[2]	Dept. of Health[2]	9, 10, 18	[1] riparian and common law doctrines apply for lands privately owned prior to 1889 [2] Game, Forestation & Parks Com. has authority where aquatic life is affected
39	Dept. of Health	Dept. of Health	Dept. of Health	Dept. of Health[2]	15	[1] does not apply to domestic use from non-artesian ground water sources [2] mining industry exempted as to tailings
40	Board of Health	Board of Health	Board of Health	Board of Health	11–15	
41	Dept. of Health	Dept. of Health; Water Conservation Com.[3]	Water Conservation Com.; Dept. of Health	Water Conservation Com.; Dept. of Health	6, 19	[1] applies only to subsurface streams [2] dams higher than 10 ft. or more than 30-acre-ft. capacity [3] Game & Fish Dept. exercises control where fish are affected
42	Dept. of Health	Dept. of Health	Dept. of Health	Dept. of Health	none	[1] in addition, Dept. of Health must approve plans of dams or diversion works used for domestic water supply

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Summary of Basic Water Use Doctrines

State	Basic Law		State Authorities			
	Surface Water	Ground Water	Surface Water	Ground Water	Dams, Diversion Works, etc.	Quality & Treatment—Public Supplies
43. Oregon	appropriation doctrine	appropriation doctrine[1]	State Engr.; Hydroelectric Com. (power)	State Engr.	State Engr.[1]; Hydroelec. Com. (power); Fish & Game Com. (fishways)	Board of Health
44. South Dakota	riparian and appropriation doctrines[1]	beneficial use rule and appropriation doctrine[2]	State Engr.; Natural Resources Com.	State Engr.; Natural Resources Com.	State Engr.	Board of Health
45. Texas	appropriation doctrine[1]	common law[2]	Board of Water Engrs.	Board of Water Engrs.	Board of Water Engrs.	Dept. of Health
46. Utah	appropriation doctrine	appropriation doctrine	State Engr.[1]	State Engr.[1]	State Engr.[1]	Dept. of Health
47. Washington	appropriation doctrine	reasonable use rule	State Supervisor of Hydraulics	State Supervisor of Hydraulics	State Supervisor of Hydraulics	Dept. of Health
48. Wyoming	appropriation doctrine	common law[1]	State Engr.[2]; Board of Control	State Engr.[2]; Board of Control	State Engr.[2]	Board of Health

and State Water Control Agencies—(contd.)

State	State Authorities (*contd.*)				Interstate Activities*	Notes
	Quality & Treatment—Industrial Drinking Water	Stream Poln. Control	Sewage Disposal—Technical	Industrial Wastes—Technical		
43	Board of Health[3]	Sanitary Authority in Board of Health	Sanitary Authority in Board of Health	Sanitary Authority in Board of Health	none	[1] east of summit of Cascade Mts. [2] except dams lower than 10 ft. or less than 3-mil.gal. capacity [3] only for more than 50 persons
44	Board of Health	Water Poln. Committee	Water Poln. Committee	Water Poln. Committee	6, 7, 18, 19	[1] navigable waters may not be appropriated [2] subsurface waters not forming definite stream (except artesian waters) subject to common law
45	Dept. of Health	Dept. of Health[2]	Dept. of Health[2]	Dept. of Health[2]	11, 12	[1] riparian doctrine applies to lands privately owned prior to 1889 [2] underflow of streams subject to appropriation [3] Game, Fish & Oyster Com. authorized to control pollution affecting aquatic life
46	Dept. of Health	no stream pollution control law[2]			14, 15	[1] Water & Power Board advisory [2] health laws permit cities to maintain jurisdiction over watersheds
47	Dept. of Health[1]	Poln. Control Com.	Poln. Control Com.	Poln. Control Com.	none	[1] smaller industrial supplies are under supervision of local health departments
48	Board of Health	Board of Health	Board of Health	Board of Health	7, 14, 15, 18	[1] except that underground streams may be subject to appropriation [2] Planning & Water Conservation Board (advisory) [3] dams above 5 ft. across running streams and all dams above 10 ft.

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Revision of Steel Pipe Specifications

The following changes, approved by the Association's Board of Directors on June 21, 1950, are to be made in A.W.W.A. Standard Specifications for Electric Fusion Welded Steel Water Pipe of Sizes 30 Inches and Over—7A.3–1940 and A.W.W.A. Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe (7A.5–1949 and 7A.6–1949).

7A.3–1940

In A.W.W.A. "Standard Specifications for Electric Fusion Welded Steel Water Pipe of Sizes 30 Inches and Over—7A.3–1940," make the following changes:

1. The designation becomes 7A.3–1950.

2. *Sec. 3–2.1.1.* Add the phrase "Grade B," after the words "A.S.T.M. Designation: 283."

7A.5–1949

In A.W.W.A. "Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe of Sizes 30 Inches and Over—7A.5–1949," make the following changes:

1. The designation becomes 7A.5–1950.

2. *Sec. 5–2.2.* Change the title of this section from "Type A Coal-Tar Enamel" to "Coal-Tar Enamel." For the first paragraph, substitute the sentence: "The type of enamel used shall be A.W.W.A. Coal-Tar Enamel." The second paragraph stands, but the following changes should be made in the table which concludes it:

Penetration. Change the values from 7 and 16 at 77°F. to 10 and 20; and from 15 and 35 at 115°F. to 15 and 55. Add a footnote reading: "For anticipated minimum temperature exposures between 20° and −20°F., use enamels with penetration of 15 to 20 at 77°F."

Peel Test. Change the statement reading "None at any temperature up to and including 160°F." to read: "No peeling."

3. *Sec. 5–2.3.* Delete the entire section and change the numerical designation of succeeding sections accordingly.

4. *Sec. 5–2.5.4(5).* This section is changed to read:

Peel Test: Two plates, 12 × 12 × ¼ in., shall be prepared as above for testing enamel. After the application of enamel the plates shall be allowed to cool to room temperature. (Tolerance of ± 2°F. will be allowed on all temperature requirements listed below.)

(a) *Bond, initial:* One test plate shall be tested directly. The condition of bond shall be tested over a temperature range of 80°–160°F. at successive intervals of 20°F.—that is, 80°, 100°, 120°, 140°, 160°F. The test shall be made at the temperatures indicated by immersing the plates for a period of approximately one-half hour in a water bath maintained at the selected temperature. At the end of each of these periods the plate shall be removed from the bath and immediately tested for peel. This shall be done as follows: With a knife edge, cut two parallel lines through the enamel approximately ¾ in. apart and approximately 4 in. in length. With the edge of the knife blade, cut under the enamel strip at one end and loosen the enamel from the plate the full width of the strip for about ½ in. Place the knife blade under the loosened end and, with a firm grip, apply a slow, steady pull upward on the enamel strip. Adhesion of the enamel at each of the indicated test temperatures, to the extent of preventing peeling, stripping or lifting, shall be recorded as no peeling. The use of the water bath for the 80°F. test may be omitted when the room temperature closely approximates 80°F.

(b) *Bond, after 72 hours at 160°F.:* The second test plate shall be stored in a horizontal position with the enameled side up, in a chamber the temperature of which shall be controlled for 72 hours at 160°F. At the end of this period the plate shall be removed and cooled to room temperature and tested for condition of bond over a temperature range of 80°–160°F. as above.

7A.6–1949

In A.W.W.A. "Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe of Sizes up to But Not Including 30 Inches—7A.6–1949," make the following changes:

1. The designation becomes 7A.6–1950.

2. *Sec. 6–1.3.2.* In the last sentence, change "(A6–2*)" to "(A6–1.2*)."

3. *Sec. 6–2.2.* Change as detailed above for 7A.5–1949, Sec. 5–2.2.

4. *Sec. 6–2.4.4(5).* Change as detailed above for 7A.5–1949, Sec. 5–2.5.4(5).

5. *Sec. 6–2.5.2.* Change the figure "13.5 lb." in the first sentence to "12.5 lb."

Electrical Conductivity

By L. V. Wilcox

A contrbution to the Journal by L. V. Wilcox, Soil Scientist, U.S. Regional Salinity and Rubidoux Laboratories, Div. of Soil Management and Irrigation, U.S. Dept. of Agriculture, Riverside, Calif.

ELECTRICAL conductivity is commonly used for indicating the total concentration of the ionized constituents of a natural water (1–3). It is closely related to the sum of the anions (or cations) chemically determined and usually correlates closely with the total dissolved solids. It is a rapid and reasonably precise determination that does not alter or consume any of the sample.

Apparatus

The apparatus consists of:

1. A wheatstone bridge, with alternating current suitable for conductivity measurements—a 1,000-cycle a-c. bridge with telephone receivers, a 60-cycle a-c. bridge with an a-c. galvanometer or one of the newer bridges employing a cathode ray tube as the null indicator.

2. A conductivity cell, of either the pipet or the immersion type, with platinized platinum electrodes. The cell constant should be approximately 1.0 reciprocal centimeter. New cells should be cleaned with chromic-sulfuric acid cleaning solution and the electrodes platinized before use. Subsequently, they should be cleaned and replatinized whenever the readings become erratic or when an inspection shows that any of the platinum black has flaked off. The platinizing solution contains 1 g. platinum chloride and 0.012 g. lead acetate in 100 ml. water. To platinize, immerse the electrodes in the above solution and pass a current from a 1.5-v. dry battery through the cell. The current should be such that only a small quantity of gas is evolved, and the direction of current flow should be reversed occasionally.

Reagents

The reagent used is 0.01*N* standard potassium chloride solution. Dissolve 0.7455 g. KCl in distilled water and make up to 1 liter at 25°C. This is the standard reference solution, which at 25°C. has an electrical conductivity of $1{,}411.8 \times 10^{-6}$ (equal 0.0014118) mhos per centimeter.

Procedure

Place four tubes of the standard potassium chloride solution in a water bath. (For subsequent sets of determinations, discard the first tube of potassium chloride solution, shift the others one place and insert a tube of fresh solution.) Place two tubes of each water sample in the bath, adjust the temperature to approximately 25°C. and hold at this temperature for 20–30 minutes. If the room temperature is not close to 25°C., it is better to adjust the temperature of the bath to approximately that of the room and hold

it at that temperature until equilibrium is attained. The bath temperature is here represented by t.

Rinse the electrode in three of the tubes of potassium chloride solution, transfer to the fourth and measure the cell resistance, R'_t. Rinse the electrode several times in one tube of the water sample, transfer to the other tube and read the resistance, R_t. The electrical conductivity (E.C.) of the sample at 25°C. is calculated from the equation:

$$\text{E.C.} = \frac{0.0014118R'_t}{R_t} \text{ mhos/cm.}$$

The numerator of the above equation ($0.0014118\ R'_t$) is sometimes referred to as the cell constant at temperature t. The value obtained for E.C. is multiplied by 1,000,000 (10^6) and reported as E.C. $\times\ 10^6$ at 25°C., or as E.C. in micromhos per centimeter at 25°C.

The expression "electrical conductivity" is synonymous with "specific electrical conductance." The standard unit for conductivity, mho/cm., is so large that most natural waters have a value of much less than 1 unit. For purposes of convenience in recording or expressing such results, the value in mho/cm. is multiplied by 10^6 (decimal point moved 6 places to the right) and reported as E.C. $\times\ 10^6$ at 25°C. The several methods of reporting conductivity are shown below, using as an example a western surface water with a conductivity of 0.00117 mho/cm:

E.C. = 0.00117 mho/cm.
E.C. $\times\ 10^3$ = 1.17 millimhos/cm.
E.C. $\times\ 10^5 = K \times 10^5 = 117$
E.C. $\times\ 10^6$ = 1,170 micromhos/cm.

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Magnitude of Industrial Demand for Process Water

By Sheppard T. Powell and Hilary E. Bacon

A paper presented on May 24, 1950, at the Annual Conference, Philadelphia, by Sheppard T. Powell, Cons. Chem. Engr., and Hilary E. Bacon, Prin. Asst., Sheppard T. Powell, Baltimore, Md.

MANY engineers are not aware of the enormous consumption of water by industry in relation to the total national demand. Although much of the water is used without purification, the aggregate of treatment plants operated by industry has an imposing daily capacity. The total industrial demand is one of the most important factors contributing to the local water shortages which have been discussed so widely in recent months.

Not only are industries large water consumers, but water-consuming industries are big business. In Table 1 is shown the "value added by manufacture" in a selected group of industries which are notably large water consumers. The "value added by manufacture," which is the difference between the value of the finished products and the cost of the raw materials, is used by the U.S. Dept. of Commerce as a true index of production by individual industries. It will be seen that the industries in Table 1, to which large water supplies are vital, account for an imposing fraction of the total of 74 billion dollars for all industries. The data are from the 1947 "Census of Manufactures" (1).

Industrial Water System Capacity

The relative importance of industry's water requirements is indicated by sales of equipment. During the past five years the total volume of sales of one manufacturer of water treatment equipment amounted to over $50,000,000. The equipment sold by various vendors includes clarification, softening and sterilizing apparatus, all of which is used in the treatment of water for industrial purposes. For five major companies in this field, the amount of business obtained from industries for the five-year period 1946–50 ranged from about 25 to 87 per cent of total sales (Fig. 1).

Many of these plants for the preparation of water to meet industry's requirements are equivalent in capacity to those serving cities of medium and large size. The plant shown in Fig. 2, which can clarify and filter 13 mgd. of river water, was recently installed by a large eastern refinery to furnish makeup for cooling towers and miscellaneous requirements. It supplements facilities previously installed which furnish filtered, softened, demineralized water for boiler feed and process use. The refinery also has an extensive well system.

It is well known that great quantities of water are required in the manufacture of paper and related products. Figure 3 shows the filtration plant of a large paper mill in the Pacific Northwest. The two standard horizontal-

flow basins in the foreground and the two round upflow tanks in the background all have equal rated capacity, a total of 44 mgd. The volume of completely treated water delivered from this plant would supply a city of almost 500,000 people. Similarly, a paper mill in the South has a filter plant in all respects equivalent to that which would be designed for a city of more than 200,000, since it has a rated capacity of about 22 mgd.

The enormous quantity of water which is used in the rayon industry must be entirely free from soluble or

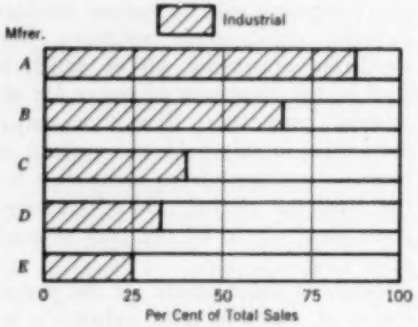

FIG. 1. Water Treatment Equipment Sales to Industry

suspended solids, which might cause stains, and must be completely softened. Cation-exchange softeners with Bitumastic * enamel- or rubber-lined shells are used to meet these requirements. The piping is rubber lined and all valves are made of nickel. Figure 4 shows the valves and piping of a completely automatic cation-exchange system which furnishes 16 mgd. of water to one of the largest rayon plants in the country.

As another example, the water treatment for a modern high-pressure boiler plant may include not only clarification and softening but practically complete elimination of all dissolved solids. A water-treating plant for feeding high-pressure boilers up to 1,250 psi. has recently been installed in a large chemical plant in the Middle West. The plant was designed to demineralize completely nearly 6 mgd. of water, at an installed cost of more than $1,500,000.

TABLE 1

Value Added by Manufacture, 1947
(Large Water Users)

Industry	*$1,000 units*
Chemicals	5,365,201
Textiles	5,340,876
Steel	2,659,250
Petroleum (refining)	1,494,474
Rubber (and rubber products)	1,302,863
Paper and board	1,050,108
Meat packing	976,995
Canning, preserving and freezing	916,621
Brewing	808,946
Dairy products	595,108
Whiskey	472,357
Soap and glycerin	450,721
Rayon manufacture	447,900
Paper pulp	415,938
Tanning and finishing	403,783
Manufactured ice	226,584
Total	22,927,725
Total all industries	74,425,825

Water Sources and Use

The four primary sources of water supply are surface water, underground water, sea water and water reclaimed from industrial or domestic sewage. The quantity of water which may be drawn from any of the above sources does not represent the entire amount used by industry. Great volumes of water are recirculated, so that the new water used may be only a fraction of industry's actual requirements. A large proportion of the supply may be

* A product of Koppers Co., Inc., Pittsburgh, Pa.

reused continuously for cooling, the only loss incurred in such service being due to evaporation, windage and blowdown. Likewise, in steam generating plants, water may be reused continuously by condensing the steam after use, the water being returned to the cycle again. Notwithstanding the conservation of supplies which can be and is effected in this way, industry's demands are enormous.

The quantity and quality of water required by industries vary so widely that each type of processing presents individual needs which must be satisfied. Practically all industrial uses of water, however, fall within one or more of the following classifications: [1] cooling, [2] processing (entering into or contacting products manufactured), [3] power generation, [4] sanitary services, [5] fire protection and [6] miscellaneous (air conditioning, washing and so forth).

Of these uses, cooling water far exceeds all others. For example, large individual electric generating stations require 500,000 gpm. of water or more for surface condenser operation. It is obvious that such volumes of water are not obtainable from underground sources or from ordinary surface sources. Well water is frequently supplied as makeup for cooling towers to replace evaporation losses. Sometimes even these requirements are appreciable. For instance, a 300,000-kw. generating station, now being planned, will require 6,000 gpm. of new water to replace evaporation losses in cooling-tower operation.

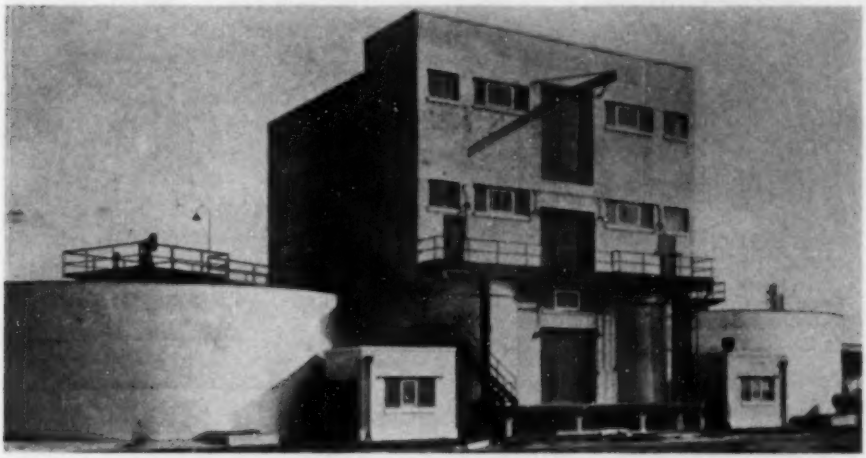

FIG. 2. Clarification and Softening Plant (Oil Refinery)

In addition to the cooling-water needs of electric generating stations, enormous quantities are required for cooling during the processing of manufactured products. There are no data from which the total volume of water used for cooling can be calculated or estimated.

Usually the volume of water actually entering into a finished, marketable product is a small portion of the total

quantity consumed. A canning company which uses as much as 2.2 bil.gal. of water per year estimates that less than 6 per cent of this quantity, or 132 mil.gal, actually contacts the processed food in such a manner that it could become part of the food product. A much larger percentage of the total volume of water used does come in contact with the food during preparatory processes like washing and soaking. Water for cooling the cans must be of good chemical quality and sterile to safeguard the flavor of the product and avoid contamination.

It is difficult to obtain figures for water consumption related directly to fire protection; however, in one large city on the eastern seaboard, where over 50 per cent of the total supply is utilized for industrial purposes, it is estimated that, out of a total pumpage of 8.3 bil.gal. a year, 1 bil.gal., or 12 per cent, was required for fire protection and flushing of the lines.

Consumption by Specific Industries

In considering the magnitude of industrial water supplies, it is of interest to estimate the annual water consumption by specific industries. Such figures have many important implications for economic development, water conservation and industrial waste problems. A complete catalog of water consumption by the many units in each industry would be a hopelessly long and difficult task, but there are statistics

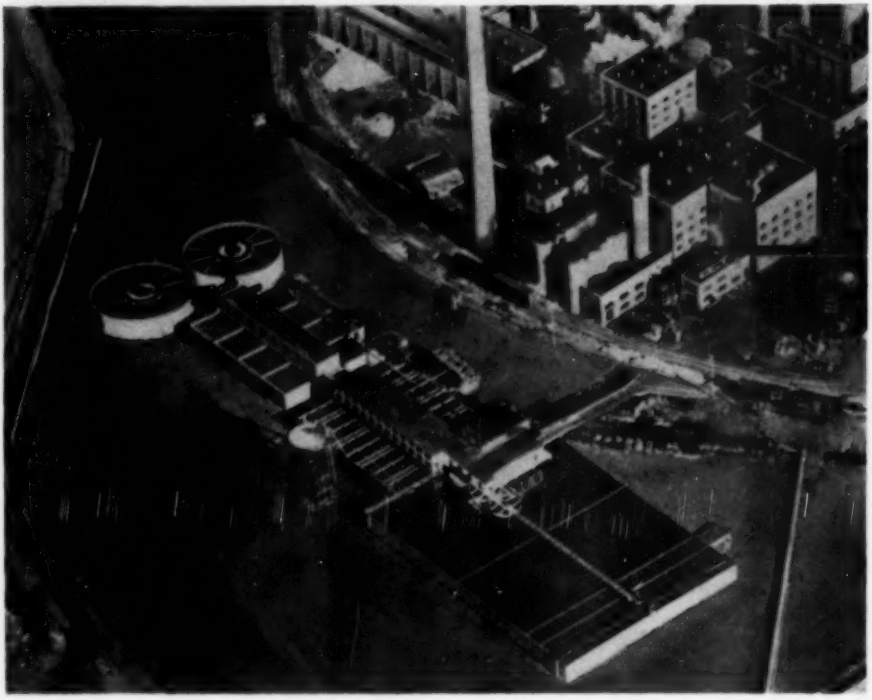

FIG. 3. Filter Plant (Paper Mill)

available from which fairly good estimates can be made.

The "Census of Manufactures" (1), previously referred to, includes not only dollar volume and payroll data but also production in units appropriate to the industry. For instance, pulp, paper and board production are reported in tons of each specific kind, petroleum is given in number of barrels refined and so on. Experts in the field of water supply and industrial waste have established rates of water consumption per unit of production for many industries (2, 3). These sources of information have been combined to prepare an estimate of water consumed by twenty selected industries in 1947, which is shown in Table 2.

Some of the census data cannot be used to estimate water consumption because the industrial operations are segregated in such a way that no consumption factors are applicable. This is true of the cotton textile industry, in which the type of product rather than the type of processing is the basis of classification. Factors are lacking for many canning and preserving processes.

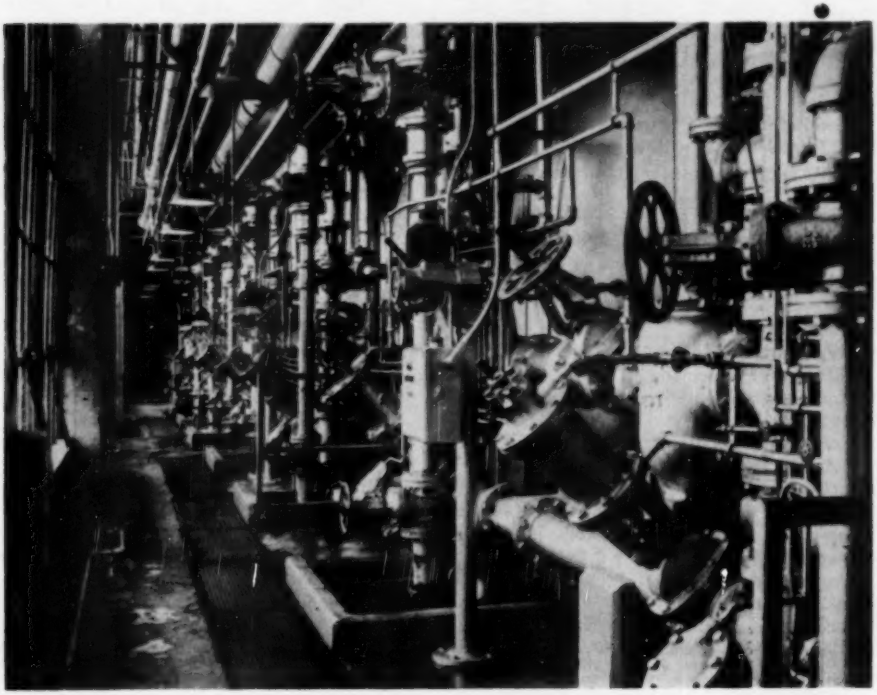

FIG. 4. Zeolite Softening Plant (Rayon Mill)

The steel industry outstrips all others in its use of water, requiring 65,000 gal. per ton of finished product (3). Next to steel in order of water use are the petroleum products, wood pulp, paper and coke industries. After these large users are the alcoholic-beverage, milk, ice and soft-drink industries. It

TABLE 2

Estimated Industrial Water Use, 1947

Industry	No. of Establishments	Value Added by Mfr. *$1,000 units*	Production		1947 Water Use (Estd.)	
			Amount	Unit	*gal./unit*	*mil.gal.*
Steel (finished)	419	2,659,250	61,857,241	tons	65,000	4,020,721
Oil refining	437	1,494,474	1,887,890,000	bbl.	770	1,452,675
Gasoline		*	791,325,000	bbl.	357	791,325
Wood pulp						
Sulfate		*	5,356,710	tons	64,000	*342,829*
Sulfite		*	2,795,960	tons	60,000	*167,758*
Soda		*	491,580	tons	85,000	*41,784*
Groundwood		*	2,049,814	tons	5,000	*10,249*
Total	226	415,938				562,520
Paper		*	10,646,833	tons	39,000	*415,226*
Paper board		*	9,186,810	tons	15,000	*137,802*
Total	665	1,050,108	19,833,643	tons		553,028
Coke	167	*	79,146,000	tons	3,600	284,493
Beer	440	808,946	88,027,000	bbl.	470	41,373
Whiskey	226	472,357	246,443,000	gal.	80	21,155
Milk, cream and butter†		*	71,440,000,000	lb.	0.11–0.25	14,286
Canning and preserving‡	2,265	609,939	391,546,000	cases	7.5–250	8,520§
Manufactured ice‖	3,423	226,584	36,100,000	tons	243.85	8,802
Soft drinks	5,618	421,000	927,700,000	cases	2.5	6,250
Woolens and worsted fabrics	495	599,534	464,563,000	lb.	70	3,252
Wool scouring	74	54,166	210,172,000	lb.	1.26	2,648
Tanning	561	403,783	238,731,000	lb.	8	1,910
Soap	249	450,721	4,138,001,000	lb.	0.25	1,034
Meat packing (hogs)	2,153	*	51,678,047	hogs	11	568
Cane sugar#	25	98,112	358,000	tons	1,000	358
Rayon (all types)	38	447,900	746,900,000	lb.	0.16	119

* Value added by manufacture is not given on same basis as production on which water consumption is based.
† Based on U.S. Dept. of Agriculture figures for creamery butter, liquid milk and cream sold in communities. No other milk products subject to water consumption estimates.
‡ Excluding fish.
§ Includes only water used in processing fourteen fruits and vegetables for which consumption factors are available. This accounts for 177,321,000 cases. Total water used by this group is probably two or three times as high.
‖ Includes filling cans and pulling cores.
Includes refining only.

is probable that, if the cotton textile industry could be included, it would fall within this intermediate group. The remaining industries in Table 2 use much smaller amounts by comparison.

The total of Table 2 accounts for nearly 7,800 bil.gal. per year, or water usage at the enormous rate of more than 21 bil.gal per day. Although only about a fourth of this amount is drawn from primary water resources, the quantities emphasize the fact that these important industries are dependent on large supplies of water, which must be considered a major limiting factor with

regard to their planning and development.

As can be seen from Table 3, the quantity of water required for each dollar of "value added by manufacture" varies widely in the industries for which data are available. Where 500–1,400 gal. of water are required for each dollar of value added, as in the steel, oil-refining and paper industries, the costs of supply and treatment are of predominant importance. On the other hand, in such industries as textiles and beverages, the ratio of water consumption to value of product is so small that more elaborate treatment can be justified.

TABLE 3

Water Used per Dollar Value Added

Industry	Water Use per $1 Added *gal.*
Steel	1,400
Wood pulp	1,352
Oil refining	973
Paper and board	527
Beer	51
Wool scouring	49
Whiskey	45
Soft drinks	15
Woolen and worsted fabrics	5.4
Tanning	4.7
Rayon	3.6

Availability of Industrial Supply

Just as no life can exist anywhere without water, neither can industry survive where water is unavailable or inadequate. When this fact, with all that it implies, is fully realized, the economic importance of water as a national resource assumes gigantic proportions. Obvious as this situation is, the wasteful practices and unintelligent allocation and use of surface and ground water in the United States are hard to understand. If proof of this condition is required, one need only to refer to the current water shortages now occurring in many sections of the nation.

The average annual rainfall in the entire country far exceeds any reasonably predictable demand for municipal and industrial water. It is estimated by the U.S. Weather Bureau that an average of about 30 in. of precipitation occurs annually over the United States. The U.S. Geological Survey records show that about 21.5 in. of rainfall soon returns to the atmosphere because of evapotranspiration and 8.5 in. runs off directly through streams or through the ground and thence into streams to the oceans. It is estimated by the U.S. Geological Survey that approximately 0.75 in. is intercepted by water users throughout the country (4), with a total consumption on the order of 100–150 bil.gal. a day. Industry uses about 5 bil.gal. of this water daily, as well as much larger amounts of recirculated water, and sea water is also used. About 25 bil.gal. a day is taken from the ground through wells, and the remainder is supplied by surface water.

TABLE 4

Effect of Expansion on Water Use

Location	Period	Pop. Increase (Estd.) *per cent*	Water Use Increase *per cent*
Baltimore, Md.	1938–48	6.0	69*
Baton Rouge, La.	1937–45	6.0	78†
Detroit, Mich.	1932–45	4.3	47*
Galveston, Tex.	1931–43	23.0	74†
Houston, Tex.	1931–43	34.0	61†
Texas City, Tex.	1931–43	63.5	2,500†

* Consumption of municipal supply only.
† Consumption of both municipal and private industrial supplies.

Basically, the conditions responsible

for the failure of water supplies to meet community requirements are:

1. Failure to provide for equalization of surface water runoff
2. Overconcentration of population and industries
3. Withdrawal of water from underground aquifers in excess of natural recharge
4. Water wastage
5. Failure to use available salt water in place of fresh water
6. Selection of plant sites without adequate evaluation of availability of water for existing or predictable future requirements
7. Inadequate design and planning of water-consuming processing equipment

The concentration of population in great metropolitan areas like New York and Los Angeles imposes an increasingly heavy burden on the total water resources. Industrial expansion has an even more striking effect, as has been observed at Louisville, Ky., and Texas City, Tex. Much of this expansion occurred during the period of war preparation. Ordnance plants were built with feverish haste and often insufficient regard for water resources, even though a standard six-line TNT plant required a 15-mgd. filtered-water supply meeting fairly rigid specifications.

It was reported recently that from 1890 to 1940, while the population of Texas increased 278 per cent, the demand for water rose over 7,000 per cent (5). Startling as is this increase, similar conditions, but of a lesser magnitude, have been experienced in many other communities, as illustrated by the statistics reported in Table 4. Where ample surface water is available or where underground supplies are not pumped at a rate in excess of the natural recharge, such increased demands can be tolerated. Whether or not these increases in water requirements can continue to be satisfied, especially from underground water, depends on how intensely industries are concentrated.

Water Waste

The American people, individually and collectively, have become the most wasteful nation in the world. This habit is demonstrated by the use of both surface and ground waters. The extent of water wastage is strikingly illustrated by a comparison of the per capita consumption of water in cities in Europe and in this country. The average per capita water rate in ten European cities, including London, Paris, Vienna, Edinburgh and Berlin, before World War II, was 39 gpd., while, in the same number of American cities, it was 155 gpd. In the latter group are New York, Philadelphia, Baltimore, Chicago and Detroit.

Much of the distress from declining water supplies could be greatly relieved by economy and drastic control of water waste. Millions of gallons of water now being wasted can be saved by reasonable conservation measures. Where conservation methods have been practiced, the cost of supervision and control has always been fully compensated for by dollar savings.

The existing water shortage in many areas is added proof of extravagance and the urgent need for concerted effort to curtail waste. Beyond the immediate financial return resulting from conservation, there are the larger and more comprehensive benefits to be gained, such as the effect on the growth and development of communities and

the overall welfare of the inhabitants. Without adequate water, specific limitations are imposed which retard all civic and industrial expansion.

Corrective Measures

Studies in locations where water supply conditions are actually or potentially critical demonstrate the need for the inauguration of the following program:

1. An inventory of individual water requirements on a national basis coordinated with actual and potential surface and ground water resources available (this survey should be both local and regional, conforming to major river basins and geological formations)
2. Discouragement of overindustrialization within critical, or potentially critical, watersheds
3. Decentralization of industrial users of large volumes of water
4. Inter- and intrastate control and regulation of flood waters to provide present and future industrial water requirements, regardless of other benefits accruing from such facilities
5. Encouragement of salt water usage as a conservation measure
6. Expansion of the activities of the state and federal agencies handling critical underground water resources
7. An increase in the number of technical personnel of the U.S. Geological Survey and provision of the necessary funds to effect more adequate utilization of the valuable services of this organization
8. Coordination of the activity of waste disposal regulation groups with allocation of water resources

The water demanded for the nation's expanding industries can and must be provided. The solution of the problem, involving as it does complex economic aspects, may be found only by an enlightened viewpoint on the part of industrial management and equitable, reasonable regulations. Such regulations must be imposed by mutual agreement and cooperative effort among those affected and through constructive, long-term planning by municipal, state and federal authorities. Within the last few years aroused public concern has prompted the assembly of much information on the subject. There are still many deficiencies, however. The data thus far compiled must be digested and additional information must be collected before an accurate evaluation of the problem can be made and controlling measures established.

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Desalting Sea Water for Domestic Use

By William W. Aultman

A paper presented on May 24, 1950, at the Annual Conference, Philadelphia, by William W. Aultman, Water Purif. Engr., Metropolitan Water Dist. of Southern California, La Verne, Calif.

THE recent water shortages which have occurred in New York, California and elsewhere in the United States have caused a renewed search for additional sources of supply for these and other regions. The emergencies bring the problem down to the level of the "man in the street," who immediately comes forth with a solution. The newspapers and popular periodicals give widespread publicity to anything pertaining to the emergency condition, and the solution by the man in the street, be he layman or qualified engineer, is announced in bold type as one which the water works authorities have overlooked or refused to investigate.

Such has been the treatment given the suggestion that supplies for domestic, industrial and agricultural purposes be obtained by the reclamation of sea water. It is not surprising that this proposal should be advanced in New York or California, where the limitless waters of the ocean are in sight. Nor is it unexpected that the ocean should be considered a logical source of fresh water, since the public is acquainted with the life raft demineralization kits and the distillation units used to supply thousands of persons on the Pacific islands during the recent war. The factor which is overlooked, however, is cost—a factor that in wartime must often become secondary to military requirements.

Where expense is not a consideration, the reclamation of sea water is practicable. A cost of $5.00 per pint for drinking water produced from sea water by the ion-exchange process aboard life rafts was inconsequential when it meant saving men's lives. The entire supply of drinking and cooking water for more than 30,000 army, navy and marine personnel on Iwo Jima was produced by various types of distillation units, as was the supply aboard many ships and on other Pacific islands. The gallon of fuel that it took to produce 15–85 gal. of potable water from sea water by such distillation equipment was a very small part of the cost of modern warfare, but even that expense was kept to a minimum by limiting the use of such water to 5–10 gpd. per person, compared with an average per capita use in the United States of about 125 gpd.

Basis for Comparison

Before discussing the various methods of sea water reclamation, a basis for cost comparisons must be established. In this paper, consideration will be given only to the cost of domestic and industrial water, for the permissible cost of agricultural water is materially less than that of the other supplies. Water rates vary widely throughout the United States. Table 1 gives a summary of a relatively recent comprehensive study (1) of water rates in

this country. It should be borne in mind that these rates include production and distribution costs and are for water delivered to the consumer's tap. The present article will use the average rate for water for industrial purposes, 10–12¢ per 1,000 gal., as the basis for comparison.

Writers sometimes like to report the cost of water as so many cents per ton, because, in those terms, it sounds like a lot of water for very little money. As a ton of water contains only 240 gal., however, a cost of 5¢ per ton is equivalent to 20.8¢ per 1,000 gal., which is not cheap.

TABLE 1

Water Rates

Monthly Use *cu.ft.*	No. of Cases Studied	Water Rate				
		Min.	Max.	Mean	Median	
		$/100 cu.ft.			*$/100 cu.ft.*	*$/1,000 gal.*
1,000	416	0.018	1.074	0.193	0.188	0.25
10,000	416	0.017	0.467	0.143	0.136	0.18
100,000	413	0.012	0.250	0.098	0.091	0.12
1,000,000	404	0.007	0.250	0.080	0.073	0.10

The three general methods of treating sea water may be grouped under the headings of mechanical, chemical and electrical processes.

Mechanical Processes

The single- or multiple-effect distillation process is probably the best known of the mechanical means and has had the widest usage of any distillation method. In normal, single-effect evaporators, heat is added to a body of water to produce steam, which is then drawn off to a heat exchanger where it is condensed to pure distilled water. This simple system has been used for hundreds of years (2). In order to increase the efficiency of such a unit, multiple-effect distillation is used. In the latter method, illustrated in Fig. 1, the condenser of the first stage forms the boiler of the second stage, from which the steam issues at a lower temperature and pressure and passes to a second condenser; this process is repeated as many times as desired or as long as sufficient temperature differentials are available to produce economical rates of heat transfer.

The fuel requirement in this type of equipment is inversely proportional to the number of effects in use, a six-effect plant roughly requiring one-sixth the fuel of a single-effect plant (3). The cost of fuel alone in a single-effect plant is about $2.60 per 1,000 gal. of distilled water and in a triple-effect plant, about $1.07 per 1,000 gal. Plant costs, however, increase in much greater than direct proportion to the number of effects, because of the increased heat-exchange surface required. Multiple-effect distillation is being used on a fairly large scale in some places where fresh water cannot be otherwise obtained and where low-cost or waste heat is available from oil development processes. The island of Curaçao, Dutch West Indies, with a population 45,000, uses six-effect distillation units. Several triple-effect units, each capable of producing 100,000 gpd. of distilled wa-

ter, are under construction to supply water to the city of Fahaheel, Kuwait, on the Persian Gulf (4). This installation is associated with oil development and presumably uses refinery wastes for fuel.

Vapor-Compression Distillation

The method which presently appears to be the lowest in cost is distillation in thermal- or vapor-compression units, known as "Kleinschmidt stills." A comparison between the fuel requirements of this method and of single- and multiple-effect evaporators (Table 2) clearly indicates the greater fuel efficiency of the vapor-compression equipment (5).

Basically this process is a heat pump system in which the latent heat of vaporization is continuously reused by compression of the vapor, thus giving the rise in temperature required for transferring heat from the condensing to the boiling section of the evaporator. Figure 2 illustrates a typical vapor-compression unit. The drive unit may be either mechanical or electrical. In the equipment of this type presently in use, optimum performance appears to yield between 175 and 200 lb. of distilled water per pound of fuel, including a fuel allowance for the mechanical or equivalent electrical power needed to drive the compressor.

One of the major problems in operating vapor-compression distillation units has been the scaling of the evaporator and heat exchangers. As the scale builds up, the efficiency of operation decreases until it is no longer economical to continue the process. A unit which at the start of operation is able to produce 200 lb. of water per pound of fuel will produce about 100 lb. of water per pound of fuel at the end of 700 hours of operation. Recent work on this problem for the army by W. F. Langelier and his associates at the University of California at Berkeley appears to have succeeded in greatly reducing this scale formation (6).

Assuming that production of 200 lb. of water is obtained from each pound of fuel (177 gal. to 1 gal.), 1 mil.gal. of water distilled from sea water would require 5,650 gal. of diesel oil or equiv-

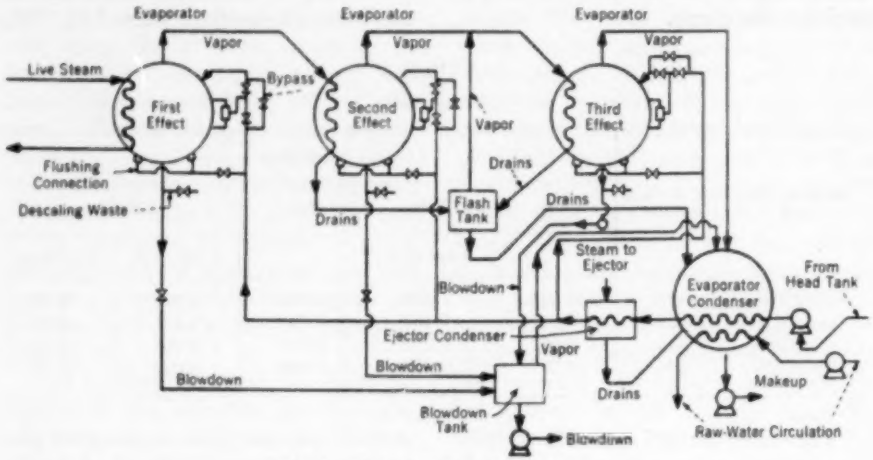

FIG. 1. Triple-Effect Evaporators

alent energy. At the lowest quotation currently obtainable for this type of fuel on the West Coast—9.5¢ per gallon, fob. refinery—the fuel cost per 1,000 gal. of water produced would be 53.7¢.

To this figure must be added the expense for labor to operate and maintain the stills, which will vary greatly, depending on the size of the installation and other considerations. Allowing for the load factors usually attainable in year-round operation of water-producing plants and for such other items as interest, amortization, depreciation and charges for pumping (since the water is produced at sea level), the total cost will be in the neighborhood of $1.25 per 1,000 gal. delivered wholesale to a local distributing agency at average distribution pressure. This amount does not include the cost of distributing the water to the local consumer. The estimated wholesale cost is about fourteen times the cost of softened Colorado River water delivered to the Metropolitan Water Dist. meinber distributing agencies in Southern California.

To produce 1,000 mgd. of potable water—the designed capacity of the Colorado River Aqueduct—would require 2,062 mil.gal. (49,100,000 bbl.) of diesel oil per year, or the equivalent, which is approximately one-fourth of California's total annual fuel oil production. Even when larger distillation units are built, the water-to-fuel ratio of 200:1 will not be materially improved, for the efficiency of heat recovery is already very high. A recent study of the problem by the Arthur D. Little Co., Cambridge, Mass., one of the foremost design and research organizations for this type of equipment in the United States, concludes that "it appears very unlikely

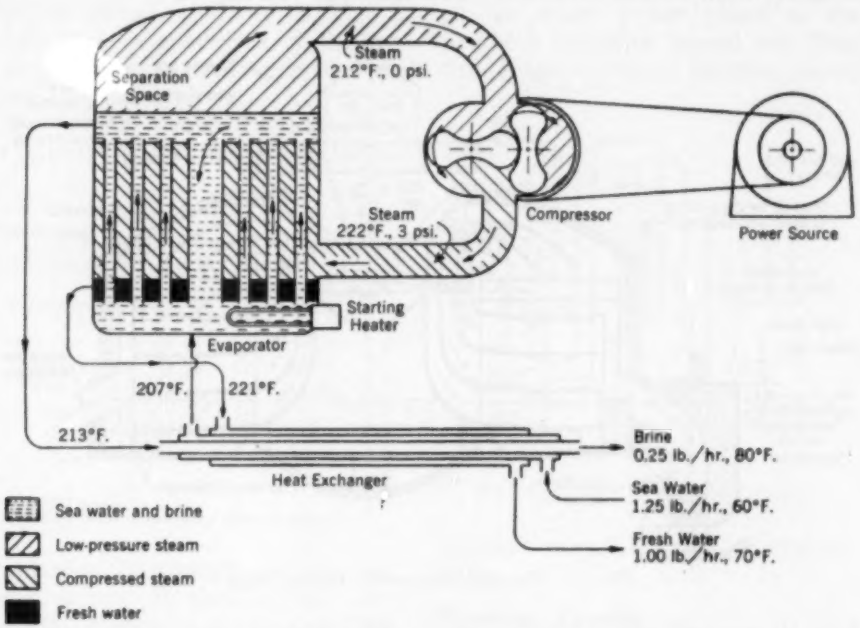

FIG. 2. Vapor-Compression Distillation

that costs can be reduced to less than half the present costs" (*7*).

Atomic Energy

Fuel and mechanical energy being the major items in the cost of distillation, the question naturally arises: "What about atomic energy?" L. A. DuBridge, Pres., California Institute of Technology, quite adequately voiced the opinion of atomic scientists when he said: "I am inclined to believe that

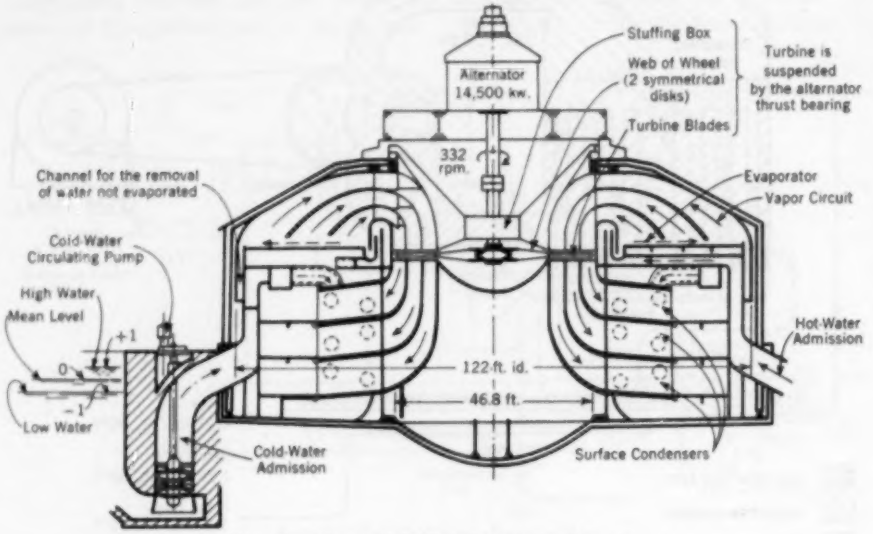

FIG. 3. Thermal Differential Power Plant

sun, waves or tides, or thermal differences in the ocean—are frequently mentioned in published articles and sound very alluring to the uninitiated. Many of them have been under investigation for hundreds of years, so far without any tangible results. R. G. Folsom, Prof. of Mech. Eng., University of California at Berkeley, believes that schemes involving such methods of power production must be looked at with care (*2*).

30 to 50 years will elapse before uranium can possibly become a major source of power" (*8*). Regarding the cost of such power when it becomes available, he stated: "Including both plant investment and fuel costs (and neglecting vast development costs) uranium power will certainly cost much more than power from coal." Power from atomic fission is not now, or in the future, likely to be used for reclaiming sea water for domestic use.

Other sources of power—winds, the

One of these methods considered by some investigators to have possibilities is the thermal differential plant of Georges Claude, designed to derive energy from temperature differences in sea water at the surface and at great depth (*9*). Differences up to 40°F. can be found where submarine canyons 1,500 ft. deep are near shore. Offshore topography is, therefore, a prime concern, and such a plant could be located only where the topography is right. A pilot plant in Cuba found

"conditions unsuitable." A second plant, being constructed by the French at Abidjan, French West Africa, proposes simultaneous development of 10,000 kw. of power and 150,000 gpd. of distilled water. Claude estimated (1930) that a 25,000-kw. plant producing 375,000 gpd. of distilled water would cost $3,000,000 to $4,000,000. A cross section of the power unit from a 14,500-kw. plant (217,500 gpd. of distilled water) is shown in Fig. 3, which gives a good idea of the tremendous size of the equipment required by this process.

Recently the Federal Works Agency, in cooperation with the Massachusetts Institute of Technology, has been testing a method of distilling sea water by solar energy in the tropics (10). Under tropical heat conditions, 4 sq.ft. of surface area is required for this purpose for each gallon of water produced per day. With the conditions prevailing along either coast of the United States, the surface area required would be about 6 sq.ft. per gallon per day. Therefore, to produce 1,000 mgd. (the capacity of the Colorado River Aqueduct), would require more than 6 billion square feet of solar pan area, which is about 138,000 acres or 215 square miles. The initial cost of such an installation, based on the reported unit cost of the equipment now under test, would be about $7,500,000,000.

TABLE 2

Fuel Consumption Comparison

Type of Evaporator	Water Produced per 1,000 Btu. *lb.*
Single effect*	0.655
Triple effect	1.590
Compression	
Motor driven†	7.930
Diesel driven	10.810

* Oil-fired boiler.
† Oil-fired boiler, condensing turbogenerator.

It was suggested that a modification of the Claude proposal might be applied to salvage some of the heat energy now discharged with the cooling water from the condensers in conventional power plants located along the coast. Studies recently made indicate that the practical recovery of heat from *all* the steam power plants in the Southern California coastal area from San Diego to Santa Barbara would produce only 1.5 mgd. of distilled water.

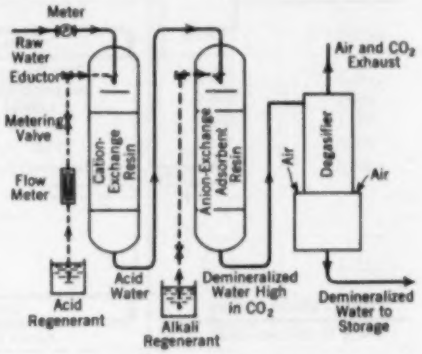

FIG. 4. Chemical Demineralization

Chemical Process

The development of organic anion and cation exchangers has made possible the complete demineralization of water (*see* Fig. 4). Their greatest use is in various process industries where the cost of such water treatment is but a small proportion of the total process cost. The cost and the feasibility of demineralization depend upon the salinity of the water before treatment.

There is much publicity in the trade journals about producing water equal

in quality to distilled water by such anion and cation demineralization. It is even stated that the cost will be as little as 26.5¢ per 1,000 gal. of water, but no mention is made of the initial quality of the water being thus demineralized. The 26.5¢ figure applies to a raw water containing only about 370 ppm. total dissolved solids, a water which is already potable. In contrast, sea water contains from 32,000 to 36,000 ppm. total dissolved solids.

includes nothing for operation, maintenance, depreciation or interest on investment. But the factor which completely eliminates this method of producing potable water from sea water is that, when treating sea water, it requires 20–30 times the amount of demineralized water produced just to wash the regenerating acid and alkali from the demineralizing material.

Recent work under the auspices of Palestine Research Associates and

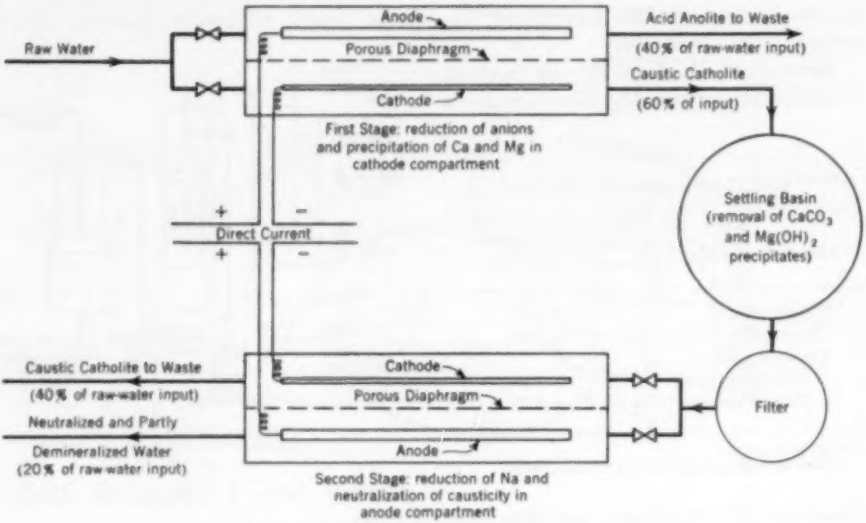

FIG. 5. Electrolytic Demineralization

The unit cost of the process is directly proportional to the salinity of the water being demineralized. The various manufacturers of anion and cation exchangers report somewhat different efficiencies of ion removal. Assuming what is believed to be a fair average operating efficiency, the cost of the regenerating chemicals (acid and soda ash or caustic soda) required to demineralize sea water, at existing prices in Southern California, would be about $25 per 1,000 gal. This figure

Ionics, Inc., Cambridge, Mass., has produced what may develop into a practical method of partially demineralizing brackish waters so that they will be potable (11). The economic limit of the present process is reached when the raw water contains 2,000–2,500 ppm. total salines, less than one-tenth the saline concentration of sea water.

Electrical Method

Another method for demineralizing water is the electrolytic process de-

veloped by Robert E. Briggs, an industrial chemist (12, 13). This is a modification of the old three-compartment electrolytic method of water treatment. It is a process which is being used for boiler water treatment and which has apparent promise in the treatment of industrial and domestic waters. A diagram of the process is shown in Fig. 5.

process would be more than twelve times the power output from Hoover Dam.

Several people, in discussing the reclamation of sea water, have mentioned the potential recovery of chemicals from the concentrated salt solutions which would be produced. In attempting to evaluate the profit from the recovery of such chemicals, it would be

TABLE 3

Sea Water Reclamation Costs and Actual Water Rates

Desalting Method	Partial Cost*		
	Item	*$/cu.ft.*	*$/1,000 gal.*
Ion exchange	chemicals only	18.70	25.00
Single-effect evaporator	fuel only	1.94	2.60
Triple-effect evaporator	fuel only	0.80	1.07
Electrolytic process	power only	0.67	0.90
Vapor-compression distillation	diesel fuel only	0.40	0.54
	Total Cost†		
Vapor-compression distillation		0.94	1.25
	Monthly Use	Actual Water Rates‡	
Municipal water production	1,000 cu.ft.	0.188	0.25
	1,000,000 cu.ft.	0.073	0.10

* Basis: bunker fuel oil—18,200 Btu. per pound, 8.34 lb. per gallon, $1.30 per barrel; diesel fuel—19,285 Btu. per pound, 7.40 lb. per gallon, $0.095 per gallon; power—$0.005 per kilowatt-hour. Allowing for pumping from sea level, labor, interest, amortization, load factor, distribution and so forth, the actual average costs might total more than three times the bare fuel, power or chemical costs.

† Cost at sea level, exclusive of distribution expense.

‡ Median for more than 400 U.S. cities (*see* Table 1).

Studies made by the inventor indicate that treating sea water requires 180 kwhr. of electrical energy per 1,000 gal. of fresh water produced. With power at 0.5¢ per kilowatt-hour, the cost for power alone would be 90¢ per 1,000 gal. As this method would require a water waste of four times the recovery, 5,000 gal. of sea water would have to be pumped for each 1,000 gal. of potable water produced. The power required to produce 1,000 mgd. by this

well to consider the effect that the production of 150 tons of salts from each million gallons of fresh water recovered would have on the present price quotations for those chemicals. Their market value would probably exceed only slightly, if at all, the considerable cost of precipitating them from the reject brine. And the disposal of 150,000 tons of salt per day from a 1,000-mgd. plant would undoubtedly become a major concern.

Distilled-water quality is not necessary for a domestic supply, but only 1.4 per cent of sea water could be mixed with distilled water and still meet the U.S. Public Health Service standard of 500 ppm. total dissolved solids for potable water. This percentage is so small that it would not appreciably affect the cost of producing a potable water from sea water.

Conclusion

A summary of the cost data presented in this paper is shown in Table 3. It is very evident from these data that presently known methods of sea water reclamation produce water costing from twelve to more than 500 times as much as the average for existing supplies.

From an engineering standpoint, there is no question that fresh water can be and is being produced from sea water. But within the foreseeable future, and in the light of current technological knowledge, there appears to be no possibility that it will be economically feasible to turn to the ocean as a source of domestic, industrial or agricultural water along either coast of the United States. Considerable sums could be spent beneficially in developing existing local supplies by conserving more flood water, by treating sewage and industrial wastes, and by continuing to develop and protect existing local supplies before turning to the ocean as a source of fresh water. This observation does not imply that research on methods of sea water reclamation presently proposed in Congress should not be encouraged, for there are many places in the world where other supplies are not available and water is vitally needed now. The supplanting of local supplies by reclaimed sea water cannot, however, be considered until the cost of sea water treatment approaches the cost of local water production.

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Discussion

Charles H. Spaulding

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The author has presented a comprehensive and well balanced picture of sea water desalting by the various methods available. He has shown that the cost of a public water supply, consisting solely of demineralized sea water sufficient for a large metropolitan community, would be astronomical. Where sources of fresh water are underdeveloped or used wastefully, other steps can be taken to augment such supplies which will be more economical than desalting sea water. On the other hand there *are* areas of the earth where adequate sources of fresh water are not available except by transport more costly than distillation.

Desalted sea water has been used to supply armed forces, for which water must be provided at whatever cost. As the author has pointed out, however, the potable-water consumption per capita may be limited to drinking requirements, and military water needs involve other unique features too numerous to mention. A recently published paper (1) gave a solution for a typical military water supply problem. At a small island air base, a catchment area, reservoir, fresh-water wells and brackish wells have been integrated to produce a nominal capacity of 9,000 gpd. This type of problem provides a legitimate field of competition for thermocompression (vapor-compression) distillation, which can substitute a standardized package plant, readily expansible when necessary, in place of uncertain and limited fresh-water sources requiring individual engineering.

Early in World War II the Water Supply Branch, Engineer Board (now known as the Engineer Research and Development Laboratories), Corps of Engineers, U.S. Army, investigated the thermocompression type of evaporator and, with the cooperation of manufacturers, developed various sizes for field application. The machines designed had capacities ranging from 60 to 300 gph. and weighed 2–7 tons per unit. They were driven by gasoline or diesel engines, from which they utilized the waste heat to start evaporation and make up heat losses from the evaporators.

At the end of the war a garrison unit of 1,250-gph. capacity was under development. This unit, now being installed at an island base, where it will supply a part of the current daily water requirements, is powered by a 150-hp. electric motor, heat losses being made up by steam from a small auxiliary boiler. It is equipped with a scale control device, called a brine stabilizer, consisting of a pressure filter 7 ft. in diameter which is operated in the backwash phase. The complete assembly weighs approximately 45 tons.

Scale and Corrosion

One of the first problems confronted in the thermocompression distillation of sea water was the scale deposited on the evaporator tubes by the boiling brine. Varying proportions of calcium sulfate, calcium carbonate and magnesium hydroxide were found or reported by different investigators, but the predominant constituent was usually magnesium hydroxide, in the amount of $\frac{1}{2}$ lb. per 1,000 gal. of distillate. This problem has been studied by Langelier and his associates at the

University of California, under a contract sponsored by the Engineer Research and Development Laboratories. Upon investigating the saturation equilibria of calcium, magnesium, sulfate, carbonate and hydroxide ions in boiling sea water, high calcium carbonate and magnesium hydroxide supersaturation was revealed. This discovery immediately suggested the use of familiar methods of desupersaturation, by which scale formation on the evaporator tubes can be retarded and perhaps eventually prevented completely. In a recent test, an evaporator equipped with an improvised stabilizer was operated for 5,000 hours as compared with the usual 700-hour limit before descaling. The method is in its infancy, and materially better equipment and results are expected as incidental problems are found and solved.

Another problem of sea water distillation is corrosion, which may occur on both sides of the evaporator tubes. On the distillate side, it adds contaminating metal to the effluent, while on the brine side it is more important as a destructive force. To deal with this problem, admiralty metal and cupronickel have commonly been used. Sometimes the surface of the tubes has been tinned on one or both sides. Corrosion is thus a rival of scale as a challenge to low-cost distillation. This subject is also being studied by Langelier and his associates, whose investigations indicate that cheaper and lighter, suitably resistant alloys are available which may decrease both the cost and the weight of the equipment.

The use of brine distillation for public water supply in Curaçao and Fahaheel has been mentioned. It was noted that these installations are employing the older, less efficient multiple-effect units. Obviously improvements in distillation equipment and methods would be a boon to such communities. The discovery and development of oil and other resources in desert areas where community life has been absent heretofore is a recent factor in the quest for brine conversion methods.

The possibility of future growth of population in some areas as a result of improved machines and methods for desalting brines should not be ruled out. Raw sea water is obviously suitable for many purposes, such as fire prevention, street flushing, sewage transport and the production of large quantities of aquatic food. If the requirements of fresh water are limited to drinking and culinary uses, distillation may enter the picture at less than prohibitive cost. It may be pointed out, also, that the heat used for the distillation of water may be used again at any temperature level below condensation. For example, a house-heating boiler could be made the source of distilled water for the home without adding anything to fuel cost. The problems of scale and corrosion, although very expensive to overcome with present equipment, may be solved satisfactorily in future, and a distilled *drinking water* supply for an entire city might be produced without any fuel cost for the distillation itself during the heating season. It might even be possible, in some latitudes, to store enough water during the heating season to last the year round. Of course, both residential heating and public water supply, as now known, would have to be radically reorganized to make any such scheme workable. Whether the need justifies the cost of exploring this field is another matter.

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Production Cost Increases

By Robert W. Williamson

A paper presented on Nov. 1, 1949, at the Kentucky-Tennessee Section Meeting, Lexington, Ky., by Robert W. Williamson, Mgr. & Treas., Water System, Columbia, Tenn.

A PROPER comparison between present costs and those of previous years cannot be obtained by dividing the total operating costs by the quantity of water produced, as production volume has so increased that the actual cost per 1,000 gal. will usually be less. It is certain, however, that the price of items making up production costs, such as labor and purification materials, has gone up. As can be seen from Table 1, the average cost of chemicals required to produce 1,000 gal. of water has increased 36 per cent since 1941. Similarly, labor costs have risen 40 per cent.

Table 2, which is a comparison of various expenses for two summer months of 1943 and 1949, shows that, *on a volume basis*, there seems to be no cause for alarm.

Since the cost of treatment materials and labor has advanced, it is evident that, if not for the increased volume, some plants would be in a serious predicament. With increasing incremental costs, either volume must continue to grow or rates must be raised.

It is probable that in some small plants, where the water revenue is incorporated into the general municipal fund and where adequate personnel does not exist for detailed cost accounting, the actual incremental production costs are not known. In other plants, the operators may be fully aware of increasing costs but are unable to remedy the situation because of the large capital expenditures required. In a number of systems which were formerly small installations with part-time pumping, replacements and enlargements have not kept up with additional requirements, and inefficiency is, of course, the result.

To find and perhaps eliminate the sources of production cost increases it is necessary to explore each part of the plant. Systems depending on lake or river supplies may be affected by stream pollution or refuse which previously did not exist but now imposes heavier duties on intake screens and cuts down pump efficiencies. As production volume increases, the clogging of screens, formerly of negligible importance, may result in somewhat higher costs. Likewise, when well supplies are used, a lowering of the water table increases the cost of power. Normally, as long as the water supply is sufficient, the saving which could be made by eliminating these conditions may not justify the capital expenditure required, especially in small plants.

A saving in pumping costs might possibly be effected by reducing the head, which would otherwise increase with a rise in the volume of water pumped. For a plant pumping 1,000 gpm. with a total head of 30 ft., the power bill would be about $79 a month (700 hours). Assuming that a 25 per cent reduction in head could be obtained at a cost of $10,000, the bond interest at 2.75 per cent would be $275

per year and the resulting power saving only $233. It is obvious that very few improvements of this type will be undertaken.

The treatment process should provide a real opportunity for saving money, particularly in view of the 36 per cent increase in chemical costs previously mentioned. There may be an inclination on the part of the plant operator to apply chemical treatment on a rule-of-thumb basis rather than in accordance with a proper control system. Although practical experience counts heavily, it would be better, now that costs have gone up, to pay closer attention to treatment requirements as indicated by tests. Adequate methods for determining the amount of chemicals needed and the proper feeding equipment should be available in every plant.

TABLE 1

Cost of Chemicals for 1,000 gal.

Item	Cost—¢		Increase	
	1941	1949	¢	*per cent*
Chlorine	8	10.75	2.75	34
Alum	1.15	1.64	0.49	43
Lime	0.4	0.5	0.1	25
Alco floc	7	9.65	2.65	38
Total	16.55	22.54	5.99	36

Even if the operator is on the alert and is introducing the right chemicals in the right amounts, the method of mixing may be deficient. In that event, a study of this condition should be undertaken and the necessary corrections made. Consideration might well be given to mechanical mixing. On the other hand, the sedimentation basins may be at fault, increasing the amount of chemicals required. Therefore, thought should be given to baffling and to the detention period. More consistent mixing and a minimum use of treatment materials might help the situation.

Improper treatment in previous steps may cause the filters to be overworked, with a resultant decrease in capacity. More frequent washing becomes necessary, requiring more wash water and more power to pump it.

The high-lift or distribution system pumps may be a source of increased production costs through failure to follow a proper pumping schedule. Such a deficiency is also reflected in supply or intake pumping costs. Another cause of rising costs which may be traced to the distribution system is the fact that the pipelines are often inadequate to deliver the larger volumes of water required by the growth in demand. The incrustation of pipelines, with consequent increased friction losses, is also a contributing factor.

TABLE 2

Production Cost Comparison

Item	Cost—¢/1,000 gal.		Change ¢
	1943	1949	
Pumping	2.88	2.48	−0.40
Purification	2.50	2.71	+0.21
Distribution	3.11	2.30	−0.81
Accounting and collecting	1.55	1.81	+0.26
Administrative and general	3.38	1.42	−1.96
Total	13.42	10.72	−2.70

In general, production costs have risen because of the increased cost of treatment, the larger volumes being pumped and the higher labor rates. This trend can be combated by closer observation of plant conditions and by more efficient operation.

NEW YORK
Herald Tribune

Friday, July 3, 1930

Strange Appointment

Mayor O'Dwyer's reasoning in public appointments is some times rather hard to follow. Take the case of James J. Moran, who has just risen to a $15,000 lifetime job as a Commissioner of the Board of Water Supply. In our present state of concern over water supply, one might assume that Mr. Moran had some special technical or administrative qualifications. If so, they are well hidden. All that can be discerned is that Mr. Moran has enjoyed a long and personal association with Mr. O'Dwyer, dating back to the days when the Mayor was a Kings County Court judge and District Attorney. As a confidential assistant and chief clerk, Mr. Moran was doubtless able. He must have impressed himself on his superior, for in 1946, by the time Mr. O'Dwyer had come to City Hall the onetime court attendant became First Deputy Fire Commissioner. And when the death of Henry Hesterberg caused a vacancy on the Board of Water Supply, the Mayor moved promptly to promote his old friend.

Commissioner Moran, it is barely possible, may become an expert on water, finding and developing new sources of supply. That, at least, is supposed to be his duty. But the appointment has set off repercussions in quite another direction. A number of Brooklyn Democratic district leaders, unconcerned by water crisis or quality of commissioners, immediately assembled over cocktails at Gracie Mansion to chart a new borough control. It was clear to them that Mayor O'Dwyer, by ignoring John Cashmore on a $15,000 piece of patronage, was looking for a new Brooklyn party leader. This, of course, is the Democrats' private fight. But it does illustrate that politics has an unseemly bearing on the water problem. Whatever Mayor O'Dwyer's internal motives in the Moran appointment, they leave an unpleasant taste. We are entitled to have top-level posts filled on better basis than personal favor and political weapon. You slipped on this one, Mr. Mayor.

Water Supply Gains; 1st Time in 11 Days

Rise Is 17 Million Gallons After Wednesday Rains

City water storage yesterday showed its first increase in eleven days, 17,000,000 gallons in the twenty-four hours ended at 8 a. m., which water department officials termed "a very slight gain."

The increase was insufficient to change the 91.9 per cent of capacity reported Wednesday, but moved the storage figure up to 232,592,000,000 gallons, according to Frank X. Elder, deputy chief engineer. Rainfall Wednesday was expected to benefit the Catskill and Croton systems by an anticipated 885,000,000-gallon runoff.

Variable rainfall over the watershed between 6 and 8 p. m. Wednesday was reported by Mr. Edler. A cloud-seeding experiment was conducted between 5:15 and 8 p. m. when a ground generator sent silver iodide smoke into the air in the vicinity of Liberty. The generator operated between Grahamsville and Grossingers airport at Liberty, sending up clouds as it traveled and continuing to operate stationary at the airport. There were light showers en route to Liberty and heavy rainfall occurred at Kingston at 6 p. m.

Better precipitation this year and lower use of water have held down the rate of storage drop compared with a year ago, according to water department figures. Storage rose slowly in the shortage and reached its high point this year of 94 per cent on June 20 and has declined gradually to the present 91.9 per cent.

A year ago the reservoirs were filled at the end of May, but fell steadily and at an increased rate to 87.6 per cent at this date when the basins held 221,698,000,000 gallons.

No comment.

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THE WALL STREET JOURNAL.

NEW YORK, FRIDAY, MAY 26, 1950

Water

To Keep Taps Flowing, Nation Must Shell Out $3,250 Million by 1960

The Cost of Protection. Rates May Mount 20% in Decade, Water Works Men Warn

Distribution Is the Difficulty

BY MICHAEL J. SAADA
Staff Correspondent of THE WALL STREET JOURNAL

PHILADELPHIA—This country is being urged to take out a $3,250 million insurance policy.

No, it's not against an A-bomb explosion or a polio epidemic.

It's against the day when you could turn on the water faucet in your kitchen sink and find nothing coming out.

That staggering sum must be laid out in the next 10 years to make sure that water will keep flowing to U. S. homes, farms and factories.

For this protection water users will have to pay a premium. Their cost for delivered water could go from today's average of 2¼ cents a person a day to 3 or 3¼ cents by 1960.

These water warnings come from men who should know—the superintendents and engineers who run the country's 15,400 water supply systems, public and private, big and little. Several thousand of them are here to attend the 70th annual get-together of their American Water Works Association.

Would Boost Construction

How do the aqua experts propose to provide the anti-thirst insurance? Through water system construction, for the most part. They caution that spending for that purpose in recent years has been a fraction of what it should be.

Louis R. Howson of Chicago's Alvord, Burdick & Howson, water system designers and engineers, says the country needs to plank down $325 million a year for 10 years to build up its water systems.

This target is finally being approached after a slow post-war start. Indications are that this year's construction spending will top $300 million. That would be about 50% above the 1949 outlay. In 1946-48, when many building materials were still in short supply, the annual average was a mere $135 million.

Use Rises with Population

By running short in some places in the past few years, water has seeped into the consciousness of millions of Americans who once took it for granted like the air they breathe. Most of them are in the East, the Midwest and the Southwest.

In parts of these regions, the race between water consumption and available supply, once no contest at all, has turned into a close affair.

In the Detroit area, says L. G. Lenhardt, general manager of the city's water board, population has increased about 30% in the past 10 years, "but we are using 45% more water now than we did in 1940." And the system, he adds, is operating at capacity.

Water consumption in Indianapolis has increased more in the past 10 years than in the preceding half-century, that city's water men say.

In Dallas, reports K. F. Hoefle, Water Department chief, "we're using nearly twice the amount of water that we did in 1940."

James E. Kerslake, Milwaukee water boss, says the city's population has risen only 12% since 1940, "but we are pumping almost 30% more water."

Other extra-thirsty areas include the New York City-northern New Jersey region, west Texas, parts of Texas' Gulf Coast and north central Illinois.

Behind the Thirst

Why the water shortages? Droughts, population increases, delays in construction because of the war and greater use of water in air-conditioning systems and in some industries.

To sustain its domestic and industrial life, the U. S. now gulps some 13,200 million gallons of water every day. The annual tonnage of consumption is 13 times as much as the 1,500 million tons of freight carried by Class I railroads last year and 32 times the country's annual output of hard and soft coal together. Daily use now is a shade above this time last year, 5.6% greater than in 1945 and 14.8% above 1940.

A big drain on reservoirs has come about through the expansion of the chemical, paper and textile industries. Next to agriculture, they swallow about as much water as any

(Continued on page 4)

Your Community

NEEDS DEPENDABLE

WATER LEVEL CONTROL

BY

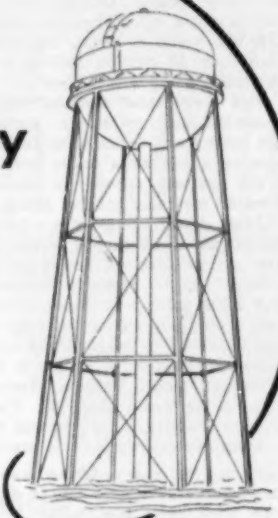
GA

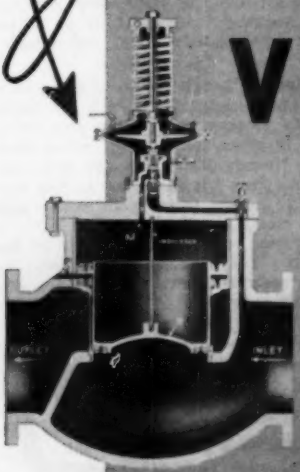
CUSHIONED

Golden-Anderson

ALTITUDE

VALVES





Golden-Anderson Water Level Control Valves give the safety and protection needed for all elevated tanks and reservoirs. These valves maintain a uniform water level and can additionally be arranged to automatically function pumps, electrical devices or signal lights. The air and water cushioning in all Golden-Anderson valves prevents any shock or hammer and permits valve to operate smoothly at all times. *Write for technical data.*

GOLDEN-ANDERSON *Valve* SPECIALTY CO.

LIFE AND PROPERTY PROTECTION

VALVES

FOR OVER 50 YEARS

(Continued from page 2)

of the nation's economic users. Their spread in the South and Southwest has put an extra load on the watersheds of many communities there.

Here's a sample of the textile mills' thirst for water: The Lyman, S. C., finishing plant of Pacific Mills uses 10 gallons for every pound (about three yards) of cloth it turns out. Since the output is about 5,500,000 yards a week, the mill consumes more than 18 million gallons a week.

Air-Conditioning a Big User

And Americans' demonstrated liking for air-conditioning in stores, homes, theatres, bars, offices and factories is pushing this convenience ahead as a water consumer; many of the systems depend on rapid circulation of water for their cooling effect.

Just how much the air-conditioning systems use in all no one knows. But this will give you an idea: A fair-sized Midwest department store recently learned it would need 2,000 gallons of water a minute to operate a proposed air-conditioning system. This would amount to nearly three million gallons a day, or enough to supply a city the size of Billings, Mont., Yakima, Wash., Rochester, Minn., or Jefferson City, Mo. The store's request to the city for water was turned down.

Such developments have made the future look dry to many towns and cities. But they're now acting to try to dampen it.

New York Plans Big Outlay

New York City, the biggest and the thirstiest of all U. S. metropolises, plans to shell out a hefty $283 million for construction in the next 10 years. It's earmarked $140 million for developing new sources and a similar amount for building reservoirs. And don't forget that $50,000 rain-making experiment going on right now. There's been rain since the cloud-seeding started, but it isn't sure whether the rain-makers deserve the credit.

Gotham's water reserves have inched up to 88% of capacity from little more than one-third last fall, but a year ago the reservoirs were overflowing. Some officials of the Water Works Association describe the city as "living on borrowed water and by the grace of God" for the past five years.

Washington, D. C., its water flow spread thin because of a big population increase, expects to pay a thumping $48 million water construction bill in the coming decade. The nation's capital has plenty of water in the Potomac River, says E. A. Schmitt, its water supply chief. The trouble, he adds, is that distribution facilities "have reached overload capacity. No one could foresee this tremendous growth in population." Not even in a city of planners.

A Shortage of Facilities

Harry E. Jordan, executive secretary of A.W.W.A., agrees that distribution generally is the difficulty. He says enough water "can be obtained any place in the United States if communities have funds for this purpose. It's not water that's short; it's the facilities to bring it to the consumers."

Houston, with a post-war boom in population and industry and its only water source a series of wells around the city, plans to spend over $20 million to develop a surface supply and to build pumping stations.

To pay for such projects, some cities are going to have to raise rates. Morrison B. Cunningham, Oklahoma City's water chief, predicts higher real estate taxes, at least for a few years, to take care of his city's $10 million expansion program.

But Mr. Schmitt of Washington says rate increases won't be needed now despite the big outlay ahead—the capital upped its rates 25% two years ago. And Mr. Hoefle of Dallas hopes his city can get by without another boost—it had a 24% raise last year.

Texas Towns Join Forces

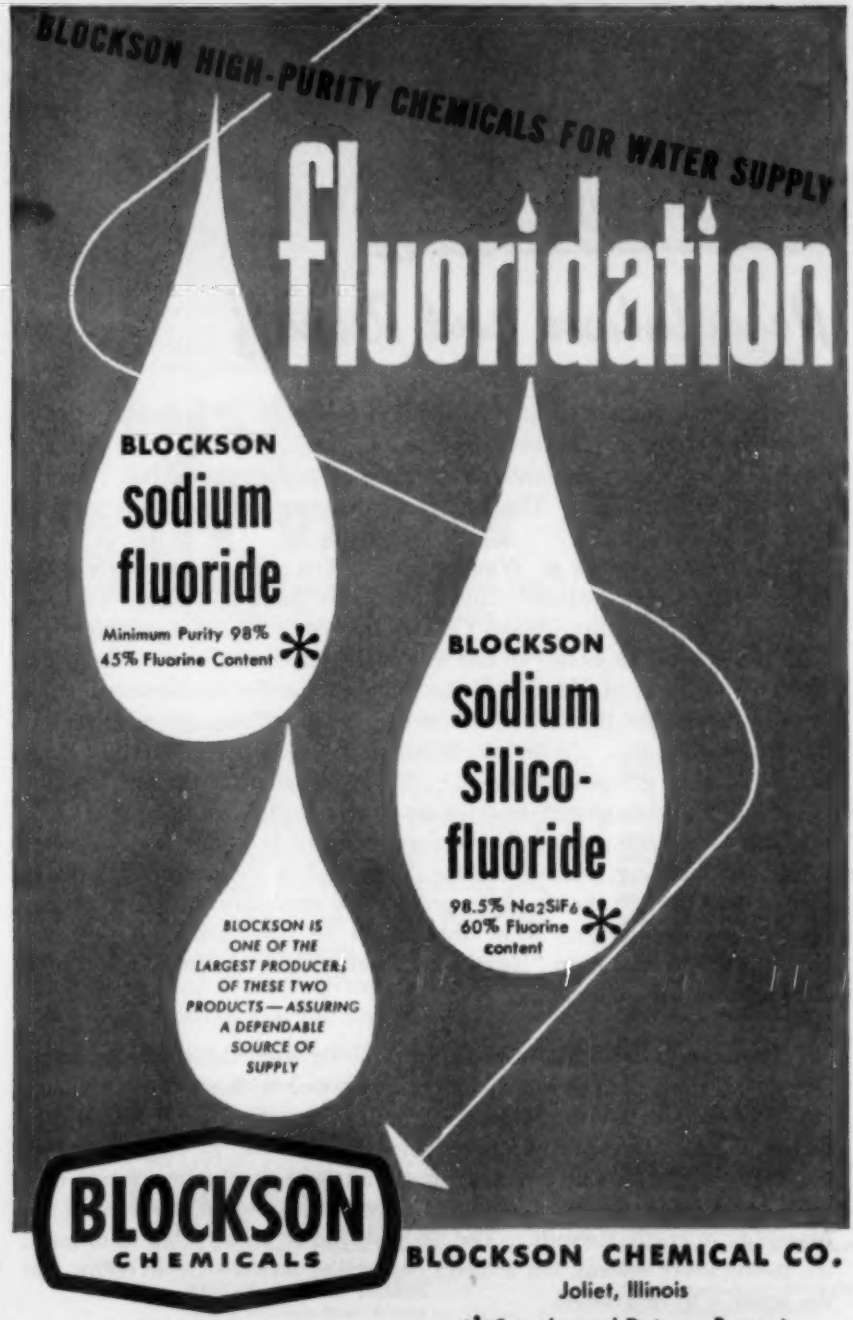
The distribution drought isn't all in the big cities. Out on the sun-parched plains of west Texas, several communities with critically low water supplies are talking up a plan to combine their resources to tap the region's Canadian River. One town alone can't afford such a project, but several can, they reason.

The scheme would be modeled on one started a few years ago in southern California. There a number of water-short communities got together and piped in an ample supply from the Colorado River, 300 miles to the east.

Los Angeles, though it's in arid southern California, has enough to quench the thirst of twice its present two million population. Its water is piped hundreds of miles from the Sierra Nevada Mountains and the Colorado River. Just the same, L. A. has earmarked $120 million to be spent in the next five years, mostly on distribution.

Des Moines, Iowa, is a wet spot on the water map. Years ago, the city built an emergency reservoir that holds a 70-day supply, and it's never had to use it yet.

The foregoing feature article, reproduced from the May 26 edition of The Wall Street Journal *because of its interest to those in the water works field, was developed by Mr. Saada, its author, after interviewing leaders of the industry who were assembled at the recent Philadelphia Conference of A.W.W.A.*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Minimum Purity 98%
45% Fluorine Content
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silico-
fluoride
98.5% Na2SiF6
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BLOCKSON IS ONE OF THE LARGEST PRODUCERS OF THESE TWO PRODUCTS — ASSURING A DEPENDABLE SOURCE OF SUPPLY
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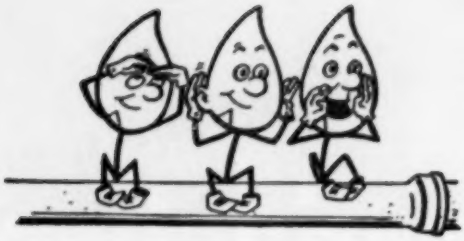
*Samples and Data on Request



Percolation and Runoff

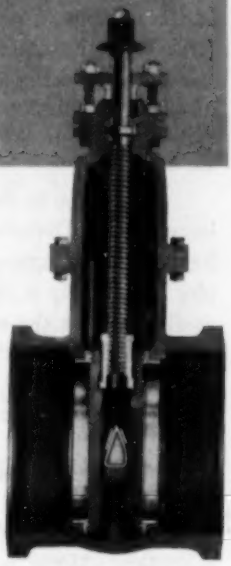
No more Indian sign. No more wet blanket. The medicine man has taken a powder. Tucked away as mere curios are the paint pot, the traditional headdress, the other ceremonial regalia for rainmaking. Everything is just . . . Ugh! The Navahos have gone and raised the scalp of our last illusion.

All this transpired at Window Rock, Ariz., last July 7, when the Navaho tribal council cancelled plans for a rain dance and signed a $2,500 contract with flying dry-iceman Charles Barnes of Phoenix, calling for a bombardment of the clouds to end a drought that had already killed from 15 to 50 per cent of Navaho sheep. Our major disappointment doesn't stem from the fact that the Navahos are "civilized" enough to give this modern magic a try. (After all, look how Chief O'Dwyer and his Manhattan worriers got pushed into it.) What does hurt is the fact that the council didn't think enough of tradition to point out, in dispensing with it, that the rain dance was really the forerunner of both dry ice and silver iodide cloud seeding, inasmuch as the dust raised by the dancers must have been sucked up into the clouds to provide the necessary nuclei for formation of rainable drops. Now, that might be considered 100-per cent Navahoism, perhaps even "Navahooey," but we, for one, would find in it a balm for injured illusions.

Damage to a Michigan residence resulting from the prolonged overflow of an elevated tank which was not provided with overflow drainage facilities is reported in the March 1950 issue of the *Michigan Water Works News*. The publication, which is issued by the Div. of Engineering of the Dept. of Health, observes that timely attention to the installation of a catch basin below the overflow outlet of such tanks would help avoid the possibility of costly lawsuits. The basin should be constructed to drain to the storm sewer system, but a direct connection between the overflow and the sewer is to be avoided.

(Continued on page 8)

The very first turn OF THE VALVE STEM unlocks the gate



Yes—the FIRST turning movement of the valve stem unlocks the VALVE WEDGING mechanism, and relieves the wedge pressure from both gates of

RENSSELAER
Double-Disc
GATE VALVES

THESE are the famous valves in which the gates are WEDGED closed, squarely and firmly, AFTER they reach the closing point opposite their seats. In opening, the wedging mechanism is positively and mechanically released, loosening BOTH gates. The additional turn of the valve stem simply lifts the LOOSENED gates into full open position.

This simple Rensselaer principle of "wedging" not only makes for ease of opening and closing but also minimizes sliding frictional wear on gate and seat rings.

Experienced Field Representatives are at your call to bring you the benefit of Rensselaer experience in Valves AND Hydrants. Their service puts you under no obligation. Call our nearest office.

TEN POINTS OF SUPERIORITY

1. Easy to Operate—No binding of Stem; Wedges independent of Stem and Stem Nut can't bind.
2. Stems and Stem Nuts both SOLID BRONZE.
3. Wedges, SOLID BRONZE in sizes 10" and larger. Wedges in these sizes have Long and Short Wedging Surfaces. Long side insures greater power in Closing. Short side, maximum ease in Opening.
4. High Tensile Strength, Corrosion Resistant Iron.
5. Stuffing Box Bolts rust-proofed. Nuts BRONZE.
6. Easy to Repack—ample stuffing box depth and diameter.
7. Minimum wear on Rings—Gates Seat, Unseat, in "fully closed" position.
8. Parallel, collapsible Discs—no sticking in closed position or binding of Stem due to tipping.
9. Interchangeable parts—due to precision Casting and Machining.
10. Long Life—Thousands still operating perfectly, some after 50 years.

LEADERSHIP FOR OVER 65 YEARS

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Hydrants • Gate Valves • Square Bottom Valves
Check Valves • Tapping Sleeves and Valves • Air Release Valves

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Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Dallas, Denver, Haverhill, Mass., Hornell, N. Y. Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle

(Continued from page 6)

Standards for propeller-driven current meters, originally adopted by A.W.W.A. as tentative specifications July 21, 1949, were advanced to standard status at a meeting of the A.W.W.A. Board on May 29. Copies of the document, which is now designated 7M.5–1950, are available from A.W.W.A. headquarters at a cost of 20¢ each. The Board of Directors also acted to disband the committee on cold water meters, which has now fulfilled its mission, but has retained Chairman Samuel F. Newkirk as "adviser."

A "Guide to Source Material on Water Pollution Control" has been issued by the Division of Water Pollution Control of the U.S. Public Health Service, Washington 25, D.C. The booklet is not in any sense a bibliography but merely a list of published material of interest, most of which is available, with the consent of the original publishers, in mimeographed or other form, under the terms of the Water Pollution Control Act of 1948. Supplements to the guide, which is dated May 1950, are expected to be issued once or twice yearly.

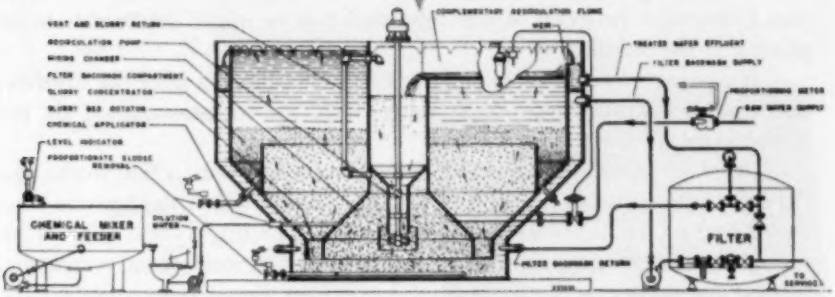
"Work horses must have water!" So has said one Alice Manchester, and even if Alice were not president of the Greenwich Village Humane League, Inc., of New York City, we'd be all too eager to agree with her. What is disconcerting, though, is her call for "a new kind of bucket brigade" to line the curbs of the metropolis with buckets of "clean, cool water" as a substitute for the twelve League-operated continuous-flow drinking troughs which had to be shut down when the water shortage struck. If only half of "all who have the welfare of horses at heart" actually heed the plea, pedestrian traffic is going to be more than a little obstructed, but he who will really kick the bucket is water-conservation-conscious Commissioner Carney. After all, it ain't hay she's talking about.

Rolf Eliassen, professor of sanitary engineering at Massachusetts Institute of Technology, has been awarded the George Westinghouse Award by the American Society for Engineering Education. The $1,000 award, sponsored by the Westinghouse Educational Foundation, is given in recognition of outstanding teaching in engineering. Dr. Eliassen served on the sanitary engineering faculties of the Illinois Institute of Technology and New York University before coming to M.I.T. last year, where he now directs sanitary engineering studies and research on both graduate and undergraduate levels.

Royden N. Aston, technical representative for Mathieson Chemical Corp. in the Chlorite Div., has transferred his headquarters from Niagara Falls, N.Y., to 334 Dixie Terminal Bldg., Cincinnati, Ohio.

(Continued on page 10)

UNIFORM TREATMENT UNDER VARIABLE LOAD CONDITIONS



THE WORTHINGTON SLURRY BED WATER SOFTENER AND COAGULATOR, TYPE CM — AN IMPORTANT DEVELOPMENT IN THE FIELD OF MUNICIPAL WATER TREATMENT

The result of extensive research and field work, the Worthington Water Softener, Type CM, features the most economical and dependable cold process slurry method available. The Type CM also serves as an efficient coagulator where turbidity and/or color removal are major requirements.

FULL RESPONSIBILITY

As makers of *complete* equipment for all four water-softening processes, Worthington not only enables you to place undivided responsibility in a single manufacturer, but can offer unbiased recommendations on the *right* process for you. For further proof that *there's more worth in Worthington*, send for literature on your particular requirements. *Worthington Pump and Machinery Corporation, Water Treating Division, Harrison, N. J.*

CHECK LIST OF ADVANTAGES

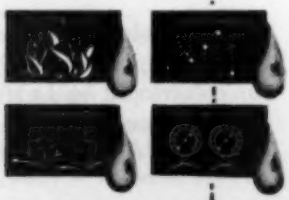
- Uniform performance under variable load conditions.
- Constant slurry bed depth.
- Maintenance of homogeneity of slurry bed.
- Control of slurry bed density.
- Full utilization of slurry before removal.
- Quick, thorough mixing assured by application of chemicals to a relatively small volume of water.
- When filters are used in softening, an adequate supply of clear treated water backwashes the filters — independent of the softening process and without loss of water.
- Symmetry of reaction tank design.
- Full retention time always maintained, because there is no deposit build-up in the bottom of the reaction tank.
- Can be furnished with dry chemical feeders and gravity filters.
- Internals of reaction tank adaptable to concrete tank construction.

JO. 4

WORTHINGTON

WATER CONDITIONING

Worthington Makes More of the Equipment for All Types of Water Conditioning Systems



(Continued from page 8)

The article in this issue of the JOURNAL entitled "Living With the Atom" (see p. 729) was one of the last things done in the writing field by Norman Beers, whose untimely death occurred on June 27, 1950.

When he graciously committed himself to participate in the Philadelphia Convention program, it was intimated that he might not be able to be present in the meeting.

His paper was completed and mailed to Philadelphia after the Convention opened—arrangements then being made for its presentation by his friend, Abel Wolman.

Beers was a brilliant scientist of the atomic age, until a few weeks ago the editor of *Nucleonics*, a former Rhodes Scholar whose degree was conferred by Oxford in the field of Astrophysics. During World War II he served the Navy as a professor of Aerological Engineering at Annapolis, leaving the service with the rank of Lieutenant Commander. When the Brookhaven Project of A.E.C. was set up, he became its key staff member in the study and control of atmospheric pollution.

Readers of his article in this issue will discern that his area of thinking went far beyond the conventional flutter over atomic bombing and seriously gave consideration to adjustment of patterns of living in the age when the nuclear physicists and the aero-physicists contrive to change the face of the earth and the time that the rains fall.

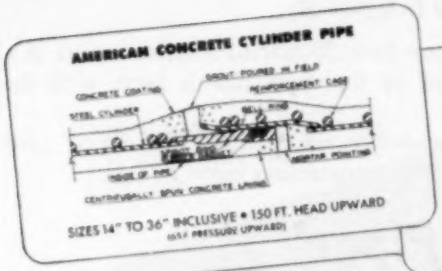
Beers died far too soon.

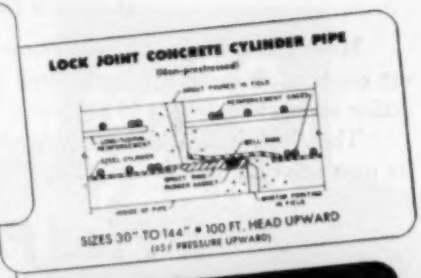
Herbert E. Hollberg, vice president of Proportioneers, Inc., died suddenly at his home in Cranston, R.I., on July 1. He. was 51 years old. A native of Sweden, he came to the U.S. after World War I as a draftsman and joined the Proportioneers organization in 1933. The following year he returned to Sweden as the company's representative, returning in 1938 to become export manager for the company. In 1943 he was made vice president of the firm and took charge of its sanitary engineering division.

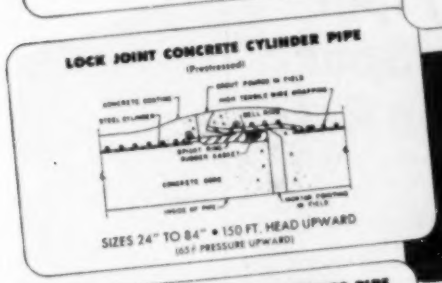
Mills Eng. Co., 10 High St., Boston 10, Mass., has been appointed to represent the American Well Works in Maine, New Hampshire, Vermont, Massachusetts and Rhode Island.

Deionized water for laboratory and other small quantity needs, in quality equivalent to triple-distilled water, is obtainable from a deionizing unit developed by LaMotte Chemical Products Co., Towson 4, Baltimore, Md. The units are made of plastic and will deliver up to 10 gal. of chemically pure water each, depending on the raw water input.

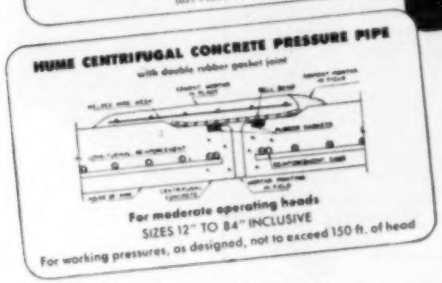
(Continued on page 12)







REINFORCED CONCRETE PRESSURE PIPE REDUCES COST OF DELIVERED WATER


HUME CENTRIFUGAL CONCRETE PRESSURE PIPE
with double rubber gasket joint
For moderate operating heads
SIZES 12" TO 84" INCLUSIVE
For working pressures, as designed, not to exceed 150 ft. of head

Combines Strength of Steel with Protection and Permanency of Concrete

Advantages in economy, sustained performance and permanency are responsible for establishing the trend toward reinforced concrete pressure pipe for main water supply lines.

For over 40 years, this company has contributed importantly to the development of reinforced concrete pressure pipe design and construction. Its products, in the sizes indicated on the diagrams, now cover the entire range of requirements common to American water works engineering practices.

There is a type to meet the needs of your project

Allowing for over-lapping from one class of pipe to another because of special conditions related to specific installations, or because of the economical range of any of the four types of pipe, the diagrams show the general field of use for each type, consistent with the factors of size and operating pressure.

Each is outstanding for its purpose. Each incorporates the physical properties of steel with the structural and protective properties of concrete, Each assures maximum economy in initial cost, ease of installation, sustained carrying capacity, trouble-free service and permanence.

Consider these advantages to your project in helping to reduce the cost of delivered water. Write for any additional information desired.

American PIPE AND CONSTRUCTION CO.

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(*Continued from page 10*)

New York City daily papers on June 28 carried announcements of a rat eradication campaign authorized by the city's Health Dept. with the active support of Mayor O'Dwyer.

The *Post*, in its brief story, headed by the caption "Pied Piper" pied its own account, as is indicated by the reproduction below:

NEW YORK POST, WEDNESDAY, JUNE 28, 1950

'Pied Piper' Set to Spur War on Rats

A new war on rats will be launched by various city departments with Col. William A. U. S. Public Health Service, acting as coordinator.

Col. Hardenbergh was named by Mayor O'Dwyer yesterday to direct the new effort to rid the city of rats. The Health Dept. reported little improvement in the problem with departments working separately.

The coordinator will have his office in the Welfare Dept. Bldg., 250 Church St., and may use home relief recipients on the project.

However greatly the press account may be confused, there is no confusion in A.W.W.A. staff thinking, which is in full support of Col. Hardenbergh in his entry into the task of overcoming one of the world's most difficult problems in the field of sanitation and food conservation.

(*Continued on page 14*)

PALMER

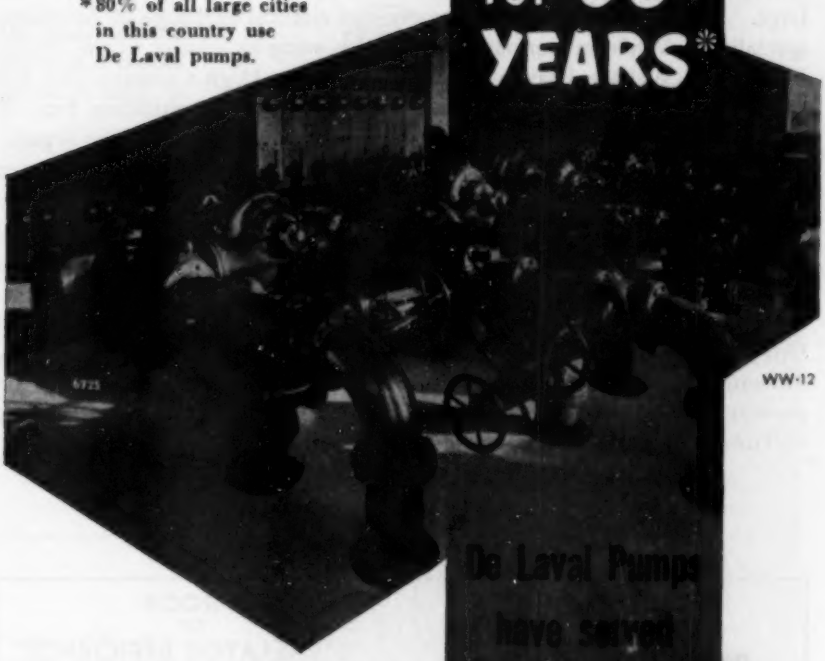
Filter Bed AGITATORS

Prevent Sand Beds From Cracking
Eliminate Mud Balls
Save Wash Water
Lengthen Filter Runs
Higher Rates of Filtration

STUART CORPORATION, 516 N. Charles Street, Baltimore 1, Md.

*80% of all large cities in this country use De Laval pumps.

for 39 YEARS*



WW-12

De Laval Pumps have served Oak Park

(Illinois)

The first De Laval pumps purchased by the City of Oak Park were installed in 1911. Two of these pumps, together with six other De Laval units purchased subsequently, deliver an average of six million gallons daily to the water mains of that city.

Write Dept. 10-12-JA.

DE LAVAL

DE LAVAL STEAM TURBINE CO., TRENTON 2, N. J.

TURBINES • HELICAL GEARS • CENTRIFUGAL BLOWERS & COMPRESSORS
CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

(*Continued from page 12*)

Jack E. McKee, associate professor of sanitary engineering at the California Institute of Technology, is leaving for Germany to make a survey of water and sewage works there, at the request of the U.S. State Dept. This activity is part of a program of cultural exchange of American specialists. While in Germany he will also serve as adviser to the Public Health and Welfare Branch of the Office of the High Commissioner for Germany. Dr. McKee was formerly active with the consulting firm of Camp, Dresser & McKee of Boston, and is still affiliated with that organization. He is expected to return to California in time for the fall semester opening.

BIF Industries of Canada, Ltd., a subsidiary of Builders Iron Foundry, has been formed for the manufacture of Venturi meters, gages, chemical feeders and other products made by Builders-Providence and Omega Machine Co. Location of the firm will be at 454 King St., W., Toronto 2B, Ont., and Canadian sales will continue to be handled by the present representatives: Keith Mercer of Montreal, Control & Metering of Toronto, and Bayfield & Archibald of Vancouver.

(*Continued on page 16*)

CARSON CLAMPS
AND PEARLITIC CAST IRON BOLTS
Stop Joint Leakage
Write for information
CARSON-CADILLAC COMPANY
1221 Pinson St. Birmingham, Ala.

PROOF
OF
"STERELATOR EFFICIENCY"

NO JOB TOO LARGE

SEND US COPY OF SPECIFICATIONS

Actual Users—THE BEST PROOF OF ALL—
Prove our claims that Everson SterElators are
DEPENDABLE · SAFE · EFFICIENT
Easy to operate at LOW MAINTENANCE COST.
Everson SterElators METER-MIX-FEED Chlorine accurately for all water sterilizing requirements.
Furnished for manual or automatic operation.
Everson SterElators utilize a high vacuum.
The indicating FLOW METERS have a 10 to 1 ratio.

SterElators by Everson

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WATCH DOG WATER METERS

The meter used by thousands of municipalities in the U. S.

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER CO.
296 South Street, Newark 5, New Jersey
SUBSIDIARY OF
WORTHINGTON
WORTHINGTON PUMP AND MACHINERY CORPORATION

(Continued from page 14)

Acute Augustiasis was what we called, two years ago, what we have right now—and what threatens to become an at least annual affliction. Two years ago it was hot and humid and we reported that only the news was unhot; last year it was hot and arid and we asked for a heated controversy re the JOURNAL cover; this year it's hot and liquid and we can report that the drought that we reported beginning last year is now ending. And that's the way things are.

No more disinterested in the beginnings of our ill than in any other subject of the moment, we harked back some 25 years of JOURNALS to the first August issue published. There, though we found no conclusive evidence of any sort, we managed to forget a symptom or two while browsing through the report of the Illinois Section meeting held with the Iowa and Wisconsin Sections at the Orrington Hotel in Evanston, Ill.—total registration, 96. Noting that President Frank C. Jordan had been too busy preparing for the Louisville annual meeting to get to Evanston as scheduled, we detoured to the "Professional Services" pages to pick out such familiar names as Allen Hazen, George Fuller and Nicholas Hill. And in the advertisement section we were rather startled to find P. W. Chapman & Co., Inc., "Underwriters and Distributors of Water Company Securities," taking a full page to invite inquiry, while Firestone used the same amount of space to sell "heavy duty pneumatics for fire apparatus." What with all the unfamiliars, it took our old friends Leadite Company on the back cover and W. W. Brush bylining the Treasurer's Report to assure us it was THE JOURNAL we had in hand.

Still on the scent of a disappearing disability, we skipped ahead some 15 years to the August 1940 JOURNAL and there again were shocked—this time to find a lead editorial on as current a topic as the use of a loyalty check in the prevention of sabotage. That was on page 1, but by the time page 50 rolled around things had deteriorated to the point of expending a quarter-page to "explain" why fire trucks are red in terms of such utter twaddle that our own Augustiasis seems almost a step toward recovery. It was our high-school history teacher who urged us to draw strength from the past.

F. M. Dawson, dean of the College of Engineering at the University of Iowa, has been elected president of the American Society for Engineering Education. Dean Dawson has for four years been vice-president as chairman of the Engineering College Research Council.

United Concrete Pipe Corp., of Baldwin Park, Calif., has been purchased by Pontusco Corp., which in turn is owned jointly by U.S. Pipe & Foundry Co. and Compagnie de Pont-a-Mousson of Nancy, France.

(Continued on page 18)

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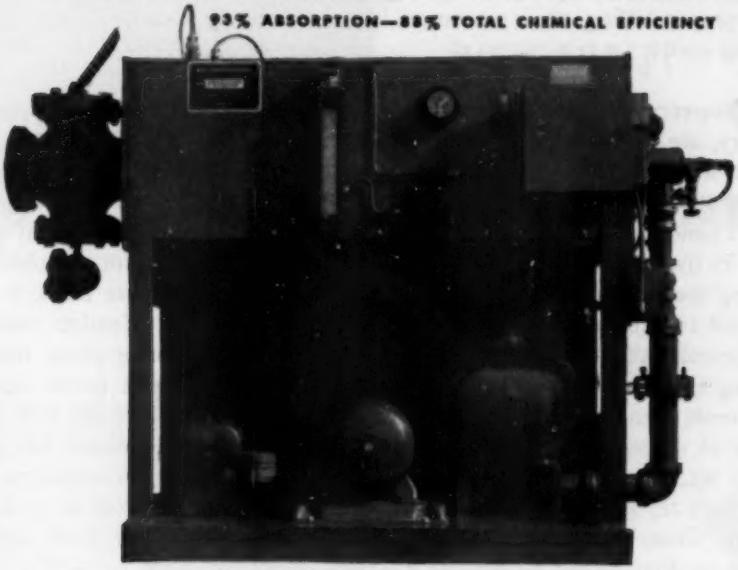

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(*Continued from page 16*)

Not just "misplaced," but misspelled as well, was the minstrel mentioned in last month's Philadelphia story (P&R p. 6). Thus we apologize to the right George (Hagetter) for giving the wrong George (Hagerty) credit. Actually, of course, the latter really is the former, misspelled (the latter, that is). Anyway, let George do it again soon and we'll promise him proper billing; this, we assure him, was merely a case of long spell wrong spell!

Supercynics extraordinary, or perhaps superstrategists just plain ornery, are the Pittsburgh district weather observers, who enjoyed themselves a wonderful picnic in a virtually deserted South Park, Pittsburgh, on the evening of last July 13, when the weather forecast read: "Showers and Thunderstorms." It isn't that we always—or ever—believe what we read in the papers, but even we haven't descended to the point of publicly calling the author of our own writings a liar. On the other hand, it is difficult to believe that respected, or at least respectable, scientists would compromise their professional veracity for the sake of some elbow room during the consumption of soggy sandwiches flavored with formic acid. We must then conclude that the wives of weather observers are even as those of others, and if we think that they're going to do dishes tonight when we. . . . Anyway clouds are inclined to be kinder to weathermen who only try to outguess them than to rainmakers who are out to exploit them. Thus, to change a sore subject, was the picnic of New York City's water workers almost a complete washout.

No water wagon available, a fellow out in Sea Cliff, N.Y., had to sleep it off somewhere. Being high himself, he chose the top of the 100-ft. city water tower. It took three fire departments—with nets—and a high-climbing human alarm clock to wake him up and get him down.

(*Continued on page 20*)

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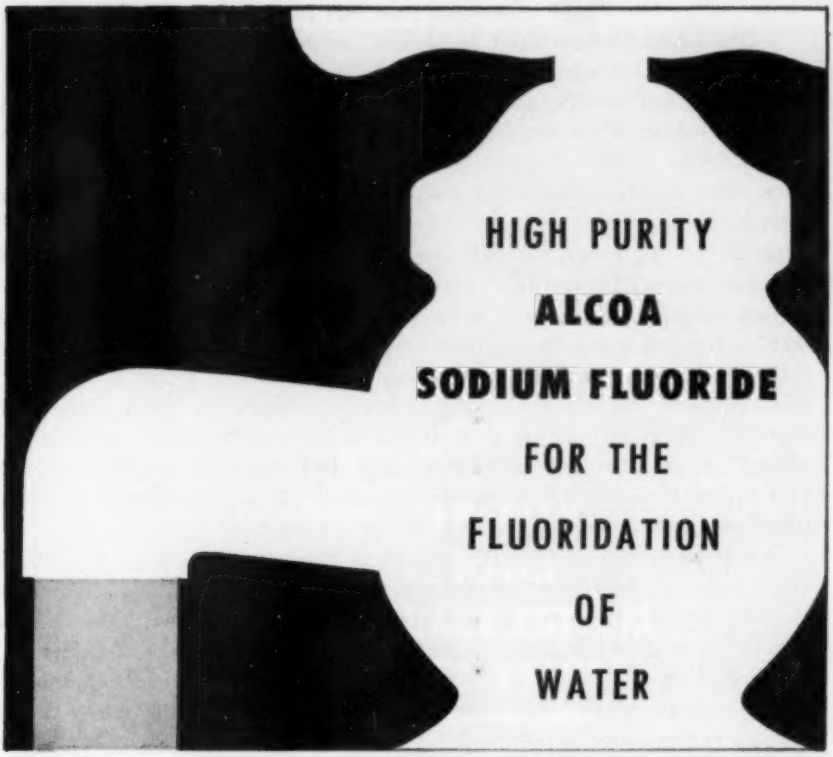

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(*Continued from page 18*)

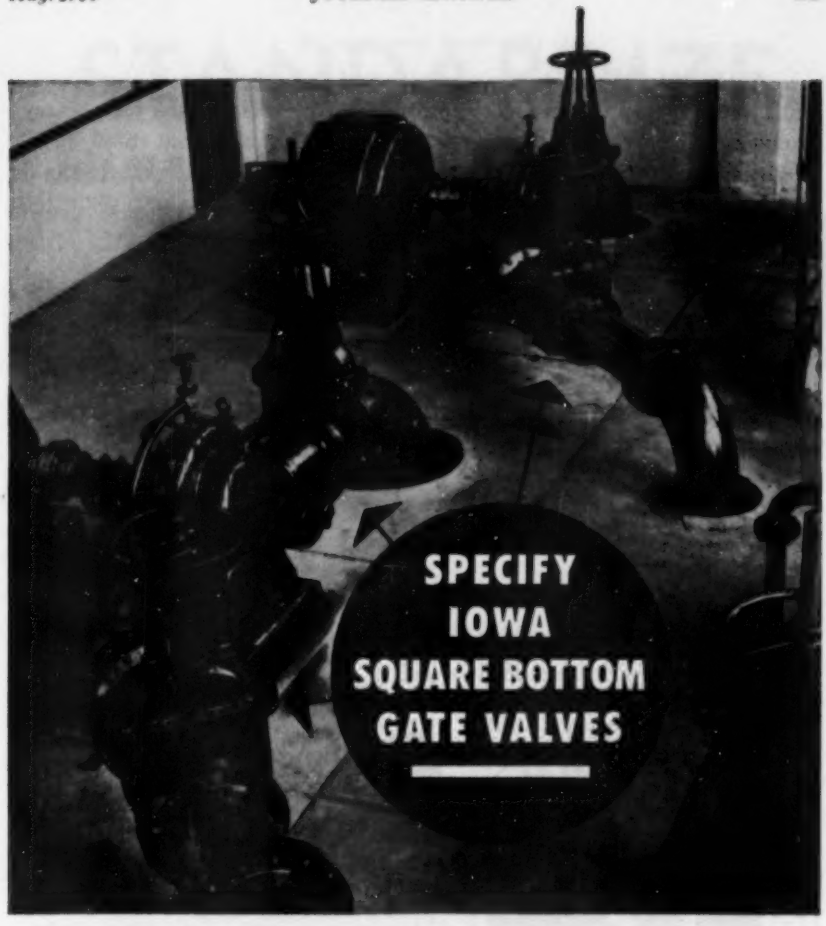
Old Lady Nature can't be blamed for getting a wee bit bewildered at some of man's demands upon her. Take that business down at Asbury Park, N.J., last month, where engineers of the Berkeley Carteret Hotel became so upset when they found their pumps delivering fresh water into the $150,000 private outdoor swimming pool they had just completed. Now, was Nature to blame for assuming that anyone wanting to swim in a pool just a stone's throw from the ocean must want fresh water? And what if the engineers did put their intake down under some 40 ft. of Atlantic, weren't they always doing some fool thing like that just because a hazel twig obeyed the laws of gravity? If there was any reason for the terrible tizzy in which the engineers ripped up their intake and started the job of relocating it without even giving her a chance to rectify a "natural" mistake, there was none for all those loud grumblings about "freaks of nature." After all, placing so mundane a label as "undersea fresh-water spring" on an attempted benevolence and then making book on it at odds of a million to one is bad enough—particularly when they could have eliminated any need for odds by asking her for a sample.

If it were only an isolated instance of this sort that caused confusion, there would be no reason for concern, but what gets the old lady down is the fact that she can't resolve the apparent conflict of man's basic desires —even on so clear-cut a subject as "fresh water from the sea." After all, turning down this supply is easily enough attributable to man's characteristic one-track mind. But how explain the lavish expenditure of time, effort and money on complicated sea water distillation apparatus, when the best and most efficient system is available free for storing its effluent. Ah well, we can be happy that Nature isn't all—or even at all—human.

A new, heavy-duty plastic pipe, called Carlon "Ex," has been developed by Carter Products Corp., Cleveland, Ohio. Designed to offer higher burst pressures and increased resistance to suction collapse, the pipe, marked with a red stripe for identification, supplements the Carlon line of plastic pipe which may be used for potable water service. The pipe comes in 2, 2½, 3, 4 and 6 in. diameters, with molded plastic fittings which permit plastic-to-plastic or plastic-to-metal connections. It retains the flexibility of the lighter grades, and can itself still be considered a lightweight pipe, since a 100-ft. section of the 2-in. pipe weighs only 61 lb. Bursting pressures for the various sizes range from 250 to 260 psi.

Thomas A. Cole, bacteriologist and superintendent of filtration for Poughkeepsie, N.Y., has retired after nearly 44 years in water supply, the last 35 being at Poughkeepsie. He also has a record of over 40 years of work in chlorination, and was associated with such water treatment pioneers as Allen Hazen, George C. Whipple, Francis Longley and Malcolm Pirnie.

(*Continued on page 22*)



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Pictured above is a series of Iowa Square Bottom Gate Valves in use at the Lincoln, Nebraska pumping station. This type of valve is recommended for throttling under conditions of greatly unbalanced pressures or high velocity flows—such as regulating flows from centrifugal pump discharge lines, reservoirs, intake towers, or wash water lines to filter beds.

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(Continued from page 20)

A 157,785,600-gal. leak was uncovered the other day in the Muncie, Ind., water system, when George Cropper in his excavations for a garage foundation dug into the basement of a house that had once stood on the site. Apparently the wreckers had forgotten to turn off the water, leaving it to flow some 45 years at the rate of 400 gal. per hour into a nearby sewer. Thus, again, if you must come a Cropper, let George do it.

John McFarland, who has been serving as assistant general manager of the East Bay Municipal Utility Dist., Oakland, Calif., since the retirement of John Longwell (January 1950 P&R, p. 10), has now been appointed the latter's successor as general manager. McFarland joined the organization in 1926 as head of the newly created Control Div. In that capacity he established modern administrative techniques for the operation of the district. A graduate of the University of Southern California, where he received a degree in public administration, he has also attended Stanford University and has held various executive posts in private industry in Southern California.

Other district changes include the retirement of Pres. Roscoe D. Jones and election of Francis E. Boyd to succeed him.

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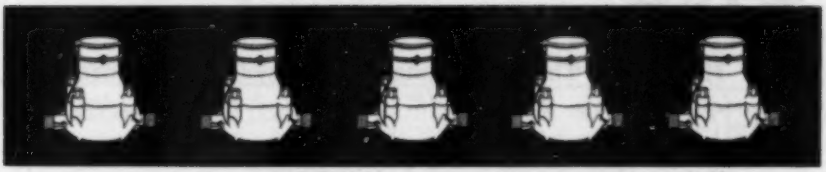

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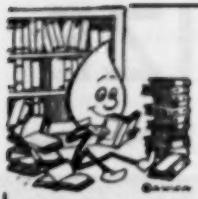

The Reading Meter

Hydrology: The fundamental basis of hydraulic engineering. *Daniel W. Mead. McGraw-Hill Book Co., New York (2nd ed., 1950) $7.50*

This work, originally published in 1919, has been revised and in some sections rewritten by Harold W. Mead, son of the author, and Henry J. Hunt, acting through the consulting firm of Mead and Hunt, with which they are associated. Some of the newer material added includes a brief discussion of artificial rainfall, the application of the theory of probability to rainfall and flood frequency data, and an investigation of the extreme minimum phases of precipitation and stream flow.

Municipal and Rural Sanitation. *Victor M. Ehlers and Ernest W. Steel. McGraw-Hill Book Co., New York (4th ed., 1950) $6.50*

In addition to the basic discussions of water supply and sewage disposal, rural and urban, the volume includes sections on insect and pest control, ventilation and air conditioning, housing and lighting, plumbing, school and industrial hygiene, swimming pools, tourist camps, and other related topics. A section on vital statistics and public health organization concludes the volume.

"Recommended Practices for Resistance Welding" has just been issued in a new and enlarged edition by the American Welding Society, 33 W. 39th St., New York 18. The text, a revision of the 1946 tentative document, is available as a 60-page booklet, designated C1.1–50, at a cost of $1.00. It includes welding schedules for spot and seam welding of mild and medium carbon steel and various alloys. Data on projection welding of low-carbon and stainless steels, and flash welding of low and medium forging strength steels is also provided.

"Speaking Can Be Easy" is the title of a compilation of helpful hints for the engineer interested in improving his oral presentation. The 24-page manual was prepared by the American Society for Engineering Education and may be obtained at a cost of 50¢ per copy from the Engineers' Council for Professional Development, 29 W. 39th St., New York 18.

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NEW MEMBERS

Applications received June 1 to 30, 1950

Andes Water Co., Earl Woolheater, Treas. & Supt., Andes, N.Y. (Corp. M. July '50)

Armacost, J. F., Salesman, Worthington Pump & Machinery Corp., 531 K of P Bldg., Indianapolis, Ind. (July '50)

Armstrong, William J., Jr., Dist. Engr., Byron Jackson Co., 316 Lloyd Bldg., Seattle 1, Wash. (July '50)

Arrowsmith, Wallace G., Village Mgr., 34808 Sims St., Wayne, Mich. (July '50) *M*

Bennett, Elbert L., *see* Big Stone Gap, Town of

Big Stone Gap, Town of, Elbert L. Bennett, Supt. of Works & Utilities, Big Stone Gap, Va. (Corp. M. July '50) *MPR*

Bremen Water Dept., Lovie Sanders, Supt., Bremen, Ga. (Corp. M. July '50)

Brewer, Louis G., Div. Supt., The Montana Power Co., 137 North Ave., E., Missoula, Mont. (July '50) *M*

Campbell, Gordon, Sales Engr., Gorman's, Ltd., 10238—104th St., Edmonton, Alta. (July '50)

Canadas, John H., Gen. Mgr., Coast Side County Water Dist., Half Moon Bay, Calif. (July '50) *M*

Cluff, Alfred J., Supt., Light & Water, Board of Trustees of Public Affairs, City Bldg., Deshler, Ohio (July '50) *M*

Conner, Eugene Lawill, Gen. Supt., Public Works & Utilities, Paris, Ky. (July '50) *M*

Cook, Donald Franz, Engr., New York Water Services Corp., 1240 Wolf St., Syracuse, N.Y. (July '50) *M*

Cox, Buford B., *see* Morse Bros. Machinery Co.

Cronin, Ralph George, Gen. Foreman, Missoula Div., The Montana Power Co., Missoula, Mont. (July '50) *M*

Dimmers, Dorothy E. (Miss), Acting Secy.-Mgr., Water & Sewage Works Mfrs. Assn., 170 Broadway, New York 7, N.Y. (July '50)

Doty, Dale M., Mgr., Culligan Soft Water Service, Box 157, Oxford, Ind. (July '50)

Eckert, Herbert L., *see* Hamden Water Works

Fonseca, Edward Leonard, Jr. Civ. Engr., Purif. Div., San Francisco Water Dept., Millbrae, Calif. (July '50) *P*

Freeman, William M., Contracting Engr., Chicago Bridge & Iron Co., 332 S. Michigan Ave., Chicago 4, Ill. (July '50)

Fulmer, Leu Relle, Jr., Sales Engr., R. D. Wood Co., 3315 High St., Little Rock, Ark. (July '50)

Garfield Water Plant Com., James A. Ricciardi, Acting Supt., City Hall, Garfield, N.J. (Corp. M. July '50) *MPR*

Goetz, Harvey J., Sales Repr., The Dorr Co., 221 N. La Salle St., Chicago 1, Ill. (July '50) *P*

Goranson, H. E., Chief Engr., Tennessee Inspection Bureau, 1034 Stahlman Bldg., Nashville 3, Tenn. (July '50)

Green, Hubert B., Mgr., Dardanelle Water Co., Box 279, Dardanelle, Ark. (July '50) *MR*

Haase, Louis, Water Filtration Plant Operator, 1008 Howden St., Muskegon Heights, Mich. (July '50) *MP*

Halkyard, Charles Cyril, Chief Engr., Humes, Ltd., 114 King St., Melbourne, Australia (July '50) *MR*

Hamden Water Works, Herbert L. Eckert, Hamden, N.Y. (Corp. M. July '50) *M*

Hamel, Alphonse, Foreman, Sandwich East Public Utilities Com., 4639 Tecumseh Rd., E., Windsor, Ont. (July '50) *M*

(*Continued on page 32*)

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(Continued from page 30)

Hardison, Clayton H., Hydr. Engr., U.S. Geological Survey, Washington 25, D.C. (July '50) *R*

Hayes, Raymond F., Pres., Lake County Water Co., 1 N. La Salle St., Chicago 2, Ill. (July '50) *M*

Hubbard, John K., Chief Engr., State House of Correction & Branch Prison, Marquette, Mich. (July '50) *MP*

Hunter, Wesley M., Supt. of Water Supply, Box 365, Port Orange, Fla. (July '50)

Hunziker, Loring T., Chief Engr., The Layne Ohio Co., 1100 W. Town St., Columbus 8, Ohio (July '50) *PR*

Jerome, Gilbert T., Pres., George Jerome & Co., 1437 National Bank Bldg., Detroit, Mich. (July '50) *MPR*

Kaske, Harry R., Operator, Washington Suburban San. Com., Hyattsville, Md. (July '50)

Keegan, W. F., Elec. Engr., English Elec. Co. of Canada, Ltd., St. Catharines, Ont. (July '50)

Kure, L. C., Owner, Water Works, Kure Beach, N.C. (July '50) *M*

Lanthier, John N., Sunset Eng. Co., Hamburg Turnpike, Riverdale, N.J. (July '50)

Malpass, Richard W., Sr., Eng. Partner, East Jordan Iron Works, East Jordan, Mich. (July '50) *M*

McDonald, James Richard, Supt., Water Works, Joiner, Ark. (July '50) *MP*

McMains, Norman L., Owner-Mgr., Soft Water Service Co., 723 N. 7th St., Terre Haute, Ind. (July '50)

Morse Bros. Machinery Co., Buford B. Cox, Mgr., Pekrul Gate Div., 2900 Brighton Blvd., Denver 1, Colo. (Assoc. M. July '50)

Mullins, Lon L., Sales Repr., Johns-Manville Corp., 2121 Eye St., Sacramento, Calif. (July '50) *MPR*

Myers, Hillis D., Owner-Mgr., Culligan Soft Water Service, St. Cloud, Minn. (July '50)

Palmer, John Vincent, Engr. & Sales Repr., Wallace & Tiernan Co., Inc., 518 Metropolitan Life Bldg., Minneapolis, Minn. (July '50) *P*

Presnell, Odell, Meter Supt., Water Dept., Ashboro, N.C. (Affil. July '50) *M*

Reber, W. McK., Gen. Mgr., The Bloomsburg Water Co., 48 W. Main St., Bloomsburg, Pa. (July '50) *M*

Reif, Fred W., Sales Repr., Diamond Alkali Co., 401 W. 17th St., Indianapolis, Ind. (July '50)

Rennau, Claude A., Water Comr., City Water Dept., Aurora, Neb. (Apr. '50)

Ricciardi, James A., *see* Garfield Water Plant Com.

Rizzi, Joseph Nicholas, Jr., Jr. Engr., Edward J. Martin Jr., Cons. Engr., 21 N. Broadway, Tarrytown, N.Y. (July '50) *P*

Robertson, John M., Pres. & Owner, John M. Robertson, Inc., Water Works Contractor, Oneonta, N.Y. (July '50)

Rohrbach, Harry L., Sales Repr., Lakeside Eng. Corp., 123 E. Woodland Ave., Ft. Wayne, Ind. (July '50)

Sanders, Lovie, *see* Bremen, Ga., Water Dept.

Seligmann, Irving Sidney, Gen. Partner, Helland & Seligmann, Ltd., Cons. Engrs., 302 Frost Bank Bldg., San Antonio, Tex. (July '50)

Smith, Chester E., Plant Chemist, Bureau of Water, Queen Lane Filters, Queen Lane & Fox Sts., Philadelphia 29, Pa. (July '50) *MP*

Spaulding, John N., Gen. Supt. of Water Systems, Pacific Gas & Elec. Co., 245 Market St., San Francisco, Calif. (July '50) *MR*

Springer, Ralph P., Salesman, Michigan Hydrant & Valve Co., 8747 Brandt, Dearborn, Mich. (July '50)

Sutphin, Roy L., Chief Operator, Sewage Treatment Plant, Virginia Polytechnic Inst., Blacksburg, Va. (July '50) *MP*

Tebar Escribano, Miguel, Chief, Meter Div., Dept. of Operation, Instituto Nacional de Obras Sanitarias, Reducto a Glorieta No. 88, Caracas, Venezuela (July '50) *M*

Tederick, George H., Comr. of Water, Cumberland, Md. (July '50) *MPR*

Teeple, Perry McKee, San. Engr., State Board of Health, Box 210, Jacksonville, Fla. (July '50) *MR*

Tirado M., Gustavo E., Supt. of Treatment Plant, Instituto Nacional de Obras Sanitarias, Reducto a Glorieta 88, Caracas, Venezuela (July '50) *MP*

(Continued on page 34)

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Tressler, Charles William, Sr. Sanitarian, Orange County Health Dept., Santa Ana, Calif. (Apr. '50) *M*

Van Tassel, W., *see* Willmar, Minn., City of

Vogt, Charles E., Asst. to Pres., Hanlon & Goodman Co., Belleville, N.J. (July '50) *M*

Webber, Harold A., Gen. Supt., 705 S. 9th, Sunnyside, Wash. (July '50) *M*

Welker, Alan Paul, Partner, Merritt & Welker, Cons. Engrs., 206 Roswell St., Marietta, Ga. (July '50) *PR*

Willmar, City of, Water & Light Dept., W. Van Tassel, Supt., 525 W. Litchfield Ave., Willmar, Minn. (Corp. M. July '50)

Woolheater, Earl, *see* Andes Water Co.

REINSTATEMENTS

Brashears, M. L., Jr., U.S. Geological Survey, Ground Water Branch, 230 Old Country Rd., Mineola, N.Y. (Apr. '44)

Christiansen, Lars E., Gen. Foreman, Metropolitan Water Dist. of Southern California, 3104 Oakshire Drive, Hollywood 28, Calif. (Oct. '43)

Eldred, Norman O., Cons. Engr., 508 Draper St., Vicksburg, Mich. (Oct. '41)

Heasley, R. G., Chemist, Water Treatment Plant, 630 S.W. 11th Court, Fort Lauderdale, Fla. (Apr. '47)

Paulson, Everett J. L., Treatment Plant Foreman, Fridley Softening Plant, 43rd & Marshall St., N.E., Minneapolis, Minn. (Jan. '41) *P*

Russell, Alexander, 170 Brunswick St., Rochester 7, N.Y. (Sept. '27)

LOSSES

Deaths

Helland, H. R. F., Cons. Engr., 302 Frost Bank Bldg., San Antonio 5, Tex. (Jan. '35) *R*

Segerstrom, Eric J., Riverbank Water Co., Sonora, Calif. (July '37)

Shaw, Frank H., Cons. Engr., 53 N. Duke St., Lancaster, Pa. (Oct. '46) *R*

Resignation

Tatum, R. L., Engr., 331 Robinson Pl., Shreveport, La. (Oct. '45)

CHANGES IN ADDRESS

Changes received between June 5 and July 5, 1950

Cary, Edmund S., Assoc. San. Engr., State Dept. of Public Health, 334 Rowell Bldg., Fresno, Calif. (July '49) *P*

Collins, Burt W., International Paper Co., Bastrop Mill, Bastrop, La. (Jan. '49)

Darby, W. A., Mgr., Eastern San. Div., The Dorr Co., Spring St., Riverside, Conn. (June '27) *R*

Decker, Curtis D., City Mgr., City Hall, Sewickley, Pa. (Jan. '49) *M*

Dohn, Charles W., 70-41—67th Pl., Glendale 27, N.Y. (Jan. '49)

Doll, Byron E., 2305 Snead Drive, Alhambra, Calif. (July '39) *MP*

Donahue, T. F., Lt. Col., Letterkenny Ordnance Depot, Chambersburg, Pa. (Apr. '30) *P*

Eck, Russell C., San. Engr., State Board of Health, 1526 Franklin St., Columbus, Ind. (Jr. M. Oct. '48)

Feagan, George H., Box 498, College Station, Tex. (Jan. '48)

Fiesler, Frederick A., Gen. Delivery, Elwin, Tex. (Jan. '44) *MP*

Freeman, Robert B., Asst. Chief Engr., American Water Works Service Co., 121 S. Broad St., Philadelphia 7, Pa. (July '43) *MPR*

Garnier, C. A., Pres., San Jose Hills Water Co., 1351 N. Covina Pass Rd., Puente, Calif. (Oct. '44) *MP*

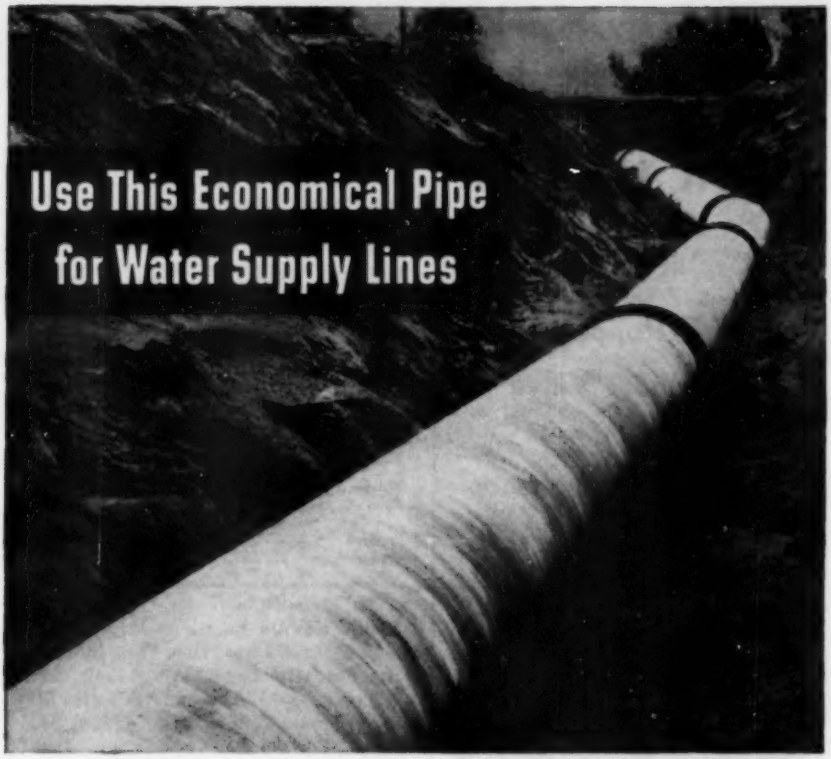
Graeser, Henry J., Jr., Asst. Supt., City Water Works, Dallas, Tex. (Oct. '45) *M*

Henderson, Kermit S., Supervisor, Filter Plant, 1222 Summit Ave., Greensboro, N.C. (Oct. '46) *MP*

Hodgson, J. L., Southern Repr., A. P. Smith Mfg. Co., 333 Candles Bldg., Atlanta, Ga. (Apr. '44)

Mason, Warren L., 1945 Clark Rd., Speedway City, Ind. (Affil. Jan. '45)

(*Continued on page 36*)



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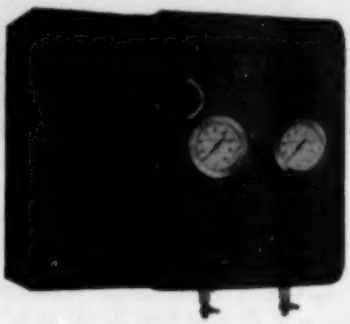

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(*Continued from page 34*)

Murdoch, John H., Jr., Vice-Pres. & Counsel, American Water Works Service Co., 121 S. Broad St., Philadelphia 7, Pa. (May '30) *Honorary M. '50. M*

Nebolsine, Ross, Pres., Ranney Water Collector Corp., 48 E. 57th St., New York 22, N.Y. (Jan. '46) *R*

Pena Duran, Luciano, Varrera 6, No. 8–67, Edificio Calero, Cali, Colombia (Apr. '46)

Pittman, William G., Co., William G. Pittman, 219 Sussex St., Hackensack, N.J. (Assoc. M. Oct. '49)

Porter, Earl, Porter, Barry & Switzer, Cons. Engrs., 1730 Main St., Baton Rouge, La. (Jan. '49)

Quick, Robert L., San. Engr., Dade County Health Dept., County Court House Bldg., Miami, Fla. (Jan. '46) *P*

Redmond, N. M., Supt. of Constr., Sewerage & Water Board, 2325 Pleasure St., New Orleans 22, La. (Oct. '45)

Reinicker, L. T., Vice-Pres., American Water Works Co., Inc., 121 S. Broad St., Philadelphia 7, Pa. (June '29)

Smith, Edward E., Water Dept., Market & Central, Lima, Ohio (July '35) *MP*

Stauffer Mfg. Co., G. W. Adams, Secy.-Treas., 2453 Merced Ave., Box 211, El Monte, Calif. (Assoc. M. Jan. '47)

Taub, Edward S., Cons. Engr., 250 E. 43rd St., New York 17, N.Y. (Apr. '48)

Thomas, Harold E., U.S. Geological Survey, Washington 25, D.C. (Jan. '49) *R*

Trowbridge, Charles E., American Water Works Service Co., 121 S. Broad St., Philadelphia 7, Pa. (Mar. '29) *P*

Wirz, Herman, Jr., Field Supt., Los Angeles Dept. of Water & Power, 14906 Dickens St., Sherman Oaks, Calif. (Oct. '43) *M*

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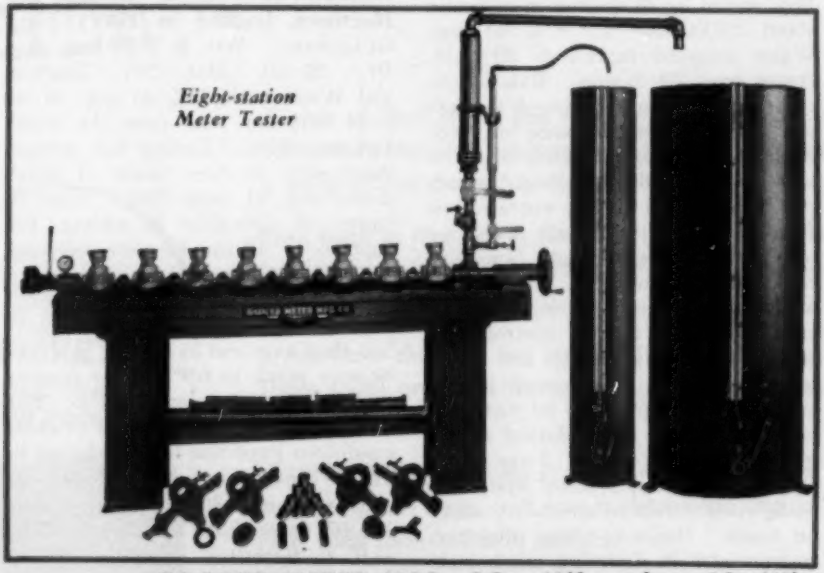

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issued dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.R.—Water Pollution Research (Great Britain).*

FOREIGN SUPPLIES

Causes of Increase in Consumption of Water. Interim Report of [British] Ministry of Health Com. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **52**:617 (Dec. '49). Report divided into [1] increase in consumption, [2] prevention of waste and [3] conclusion, including summary of recommendations. Ends with appendix giving water consumption in '38–'48 in certain utilities in England, Wales and Scotland. Pop. served by 26 utilities in appendix about 20,000,000—i.e., 42% of pop. Water supplied represents 20% increase over '38 figures. Rate of increase before war continued through war years. After allowance for justifiable consumption, appears there is loss of 3–10 gpd./cap. (Imp.) which can be attributed only to waste in one form or another. Leakage accts. for only part of water wasted. Some due to deterioration of underground mains. In domestic fittings, experience shows that lack of control leads to use of inferior fittings and workmanship. Need for training inspection staff could probably be met most satisfactorily by establishment of regional training centers. Some water engrs. regard waste meter system as being most effective means of attack on waste. House-to-house inspection instrumental in detecting much leakage. Suggested that national campaign of propaganda against waste would help reduce unnecessary consumption. Recommendations for prevention of waste: [1] intensification of waste detection and prevention; [2] requirement that water taken from public supplies for industrial use be recirculated, if suitable nonpotable supplies unobtainable; [3] encouragement of consumer cooperation by wider publicity, with injunctions to avoid waste reserved for times of severe shortage; and [4] initiation of research on all promising waste-detecting devices, funds being made available from central sources.—*H. E. Babbitt.*

Rainfall Over Great Britain and Northern Ireland in 1949. JOHN GLASSPOOLE. Wtr. & Wtr. Eng. (Gt. Br.), **53**:121 (Mar. '50). England and Wales with 87% of avg. in '49 drier than any year since '33, which had only 81%. During last century there were 10 drier years, of which driest was '21, with 70%. Some of causes of difficulties in maintg. full supplies in '49 can be more fully appreciated by considering incidence of rainfall throughout year. Over England and Wales 7 of first 9 mo. gave less than avg. and by end of Sept. deficiency amtd. to 6.9". Over country as whole, each month, other than March, warmer than usual. These conditions gave rise to large losses by evapn. Over England and Wales seasonal year, with 76%, was driest since '06–'07, apart from '20–'21 with 72%. —*H. E. Babbitt.*

Domestic Hot Water Supply. [British] Ministry of Works Survey. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **53**:227 (May '50). 7% of households in Britain have no piped water, 1% have hot water laid on from

(*Continued on page 40*)

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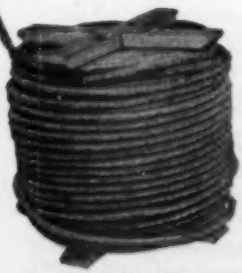

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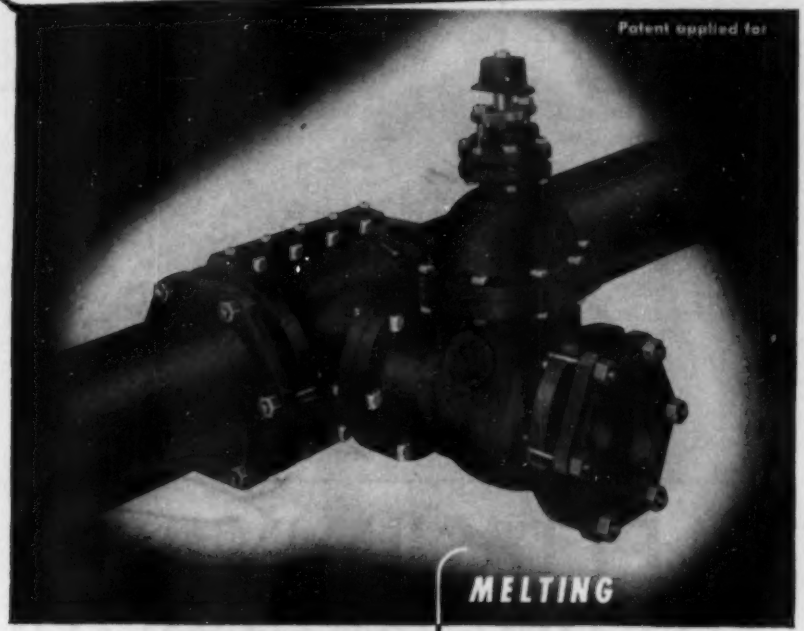
(Continued from page 38)

central source. Only 46% have bathrooms, 8% share bathroom. 15% have no water-heating appliance. 56% use kettles and pans to heat water. For dishwashing, 60% of households use kettles and pans on stove, 22% use solid fuel fire with oven, 6% geyser or other gas appliance and 5% elec. appliance. Some conclusions based on results of survey of 6000 representative households carried out by ministry during severe winter of '47 (information obtained in 20-min. interviews with housewives): Regional differences observed in distr. of appliances and their uses. Solid fuels less frequent in south. Shared bathrooms relatively common in London. In north, solid fuel fire with oven and boiler most often found for heating water. Next most popular method, open fire with boiler. In general, immersion water heater thought most satisfactory by highest proportion. Chief complaints made about open fire with boiler and oven-heated boilers were that water took too long to get hot, did not get hot enough and there was not enough of it. Most frequent complaint about gas and elec. storage heaters was that they did not provide enough hot water at one time. Nearly half of those with solid fuel boilers dissatisfied.—*H. E. Babbitt.*

Increasing London's Water Supply. C. B. FAWCETT. Wtr. & Wtr. Eng. (Gt. Br.), **53**:71 (Feb. '50). Concn. of 10,000,000 people in London, together with improved stds. of living, has increased, and probably will double, present rate of water demand per capita. Present rivers and underground sources evidently inadequate. Might aim at doubling supply now available in period of "low" Thames and at same time double total again in next 50 yr. Avg. annual rainfall of 20" may be taken as min. needed. Avg. over London and Thames Valley to east is 20"–25". Over rest of English lowlands, normally 25"–30". Hence, any substantial addn. to London's water supply can be obtained only from western highlands, nearest of which is 150–200 mi. away. Large part of water from that highland gathered by headstreams of Severn R. Upland area of Cotswolds physical barrier between Severn and Thames. Proposed that water be taken from Severn here and discharged into Thames. Scheme involves lift of nearly 200' to summit reservoir and thence flow by gravity through aqueduct-tunnel to outfall into Thames at Abingdon. London would probably have sufficient water for present generation. If removal of so much water from Severn below confluence of Stratford-on-Avon allows tidal water to come upstream to intake, may be necessary to build weir to exclude sea water. To take water from reservoir fed from channel of Severn would cause least interference with navigation, allow some settlement of suspended matter and decrease length of aqueduct to summit reservoir to about 6 mi. From there to Thames 38 mi. in straight line. So long as water added to Thames does not exceed that necessary to keep channel full, no difficulties in its passage downriver. One of many conceivable alternatives is to use shorter tunnel at greater altitude. If water lifted 400' above sea level, it could be taken by tunnels only 10 mi. in length and discharged into R. Churn of Coln. Cost of extra pumping lift and addn. of such vol. of water would produce difficulties. Waters of Severn pold. and should be purified before entering Thames. However, natural purif. probably best practicable method of dealing with ordinary river water. Increase as here suggested could have only beneficial effects on amt. of water in underground reservoir beneath

(Continued on page 42)

THE FIRST MECHANICAL JOINT TAPPING SLEEVE AND VALVE



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A new all Mechanical Joint Tapping Sleeve and Valve, installed quickly and easily even by untrained workmen. The only installation equipment necessary is a 10" ratchet wrench and a standard open end wrench.

There are no joints to pour or caulk.

Installation can be made in wet trenches in any kind of weather.

The "Stuffing Box" type joints require no cutting or scarfing of rubber gaskets on job.

Assemble Sleeve on main—attach the Valve, the installation is complete, ready for tapping and the joints are permanently bottle-tight.

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CHECK VALVES
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WATER SERVICE BRASS GOODS

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FLOOR STANDS
INDICATOR POSTS
TAPPING MACHINES
INSERTING MACHINES
PIPE CUTTING MACHINES
CORPORATION TAPPING MACHINES

(*Continued from page 40*)

London Basin. Problem of London's water supply part of wider problem of southeast quadrant of England now contg. nearly ⅓ of pop. of Great Britain. Its inhabitants increasing more rapidly than those of country as whole. —*H. E. Babbitt.*

Water Resources of the Yorkshire [England] Chalk. C. GREEN. Wtr. & Wtr. Eng. (Gt. Br.), **53**:114 (Mar. '50). Pop. of about 420,000 on 1174 sq.mi. of East Riding of Yorkshire requires water chiefly for domestic and farm use, except in Hull and Beverley, where many industries require large quants. Capac. of Yorkshire Wolds as watershed can be estd. from: area of absorbent surface, avg. annual rainfall, and amt. of percolation. Outcrop of chalk or area of absorption about 420 sq.mi. Avg. annual rainfall varies from about 24.5″ in lower-lying parts up to 33.5″ in high wolds. Overall avg. 30.6″. Percolation from 20 to 80% of rainfall. Rainfall lost by evapn. is, like percolation, impossible of direct measurement. From study of information, formula can be deduced that evapn. at Bransdale equals rainfall plus 5″. Calcns. based on percolation of 12″ only. Even this conservative est. indicates 144 mgd. (Imp.) available as source of water supply. Porosity of chalk such that there is storage of about 1 gal. (Imp.) in each cu.ft. Water will not run out of pores and useless as source of supply. Main flow of water takes place through joints and fissures. To obtain water from chalk, usual to construct boreholes, wells or adits. In constructing pumping stations at Dunswell and Cottingham, dry adits driven. Cause

(*Continued on page 44*)

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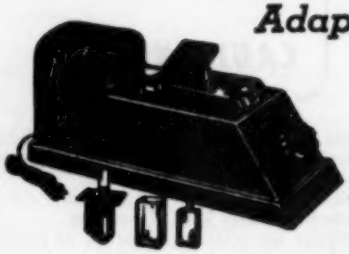
ELECTRIC PHOTOMETER



Adaptable for Use in Water Analysis

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

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(*Continued from page 42*)

attributed to interference between pumping stations. Conditions existing sometimes known as "perched water table." Adits constructed at too great depth. Little doubt that in area around Dunswell and Cottingham available water in top broken chalk. There is available from chalk vast quant. of water, of excellent qual., sufficient to meet all domestic and trade requirements of any pop. likely to inhabit area within foreseeable future.—*H. E. Babbitt.*

Hydrology of the Vienna Basin South of the Danube. H. KUPPER. Gas, Wasser, Wärme (Austria), **4**:51 ('50). On basis of older anals. attempt made to correlate chem. compn. of ground water with geological formations. Conductivity of water plays important role as function of chem. compn. of water, allowing grouping of ground water in different types. Appears that rain water in calcareous formations follows faults and is converted to hard water in short time, except in one well with soft water in center of hard-water region. Explanation probably that water obtained from connecting subterranean caves.—*Willem Rudolfs.*

Community Distribution Net for Blénod-les-Pont-à-Mousson [France]. J. PERSON. L'Eau (Fr.), **36**:193 (Dec. '49). Beginning being made to supply rural communities in France with water. Town of Mousson has 2500 people, using about 12,000 gal., or less than 5 gpd./cap. Well drilled, reservoir constructed and double line installed: pressure line to reservoir and distr. line, solving problem economically.—*Willem Rudolfs.*

The Larvotto Pumping Station in the Principality of Monaco. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **53**:109 (Mar. '50). Under new plan, pumping station erected at Larvotto about 900 yd. east of Casino of Monte Carlo. Location fixed by Vaulabelle springs, slightly above sea level, into which sea occasionally finds its way. Two independent distr. systems used; one for drinking water with capac. of 1620 gpm. (Imp.), other for service water with slight salt content, capac. 2370 gpm. (Imp.). Pumping station built on caisson 23′ below mean sea level. Basement contains potable-water reservoir with floor 13′ 6″ below sea level. Floor of middle story is 2′ 4″ above sea level and accommodates incoming pipes, vertical pumps and discharge pipes. Top floor, 20′ above sea level, supports elec. motors, control panels and operating and supervising equip. Six Sulzer well pumps, arranged in groups of two, each raise 805 gpm. (Imp.) from reservoir against head of 380′. Protective switches assure safety of plant; for example, prevent starting up of pumps when valve in discharge line open or suction closed. Motors automatically stopped in event of change of phase or drop in voltage.—*H. E. Babbitt.*

Potable Water Supply in Grand Duchy of Luxembourg. THEODORE SUNNEN. Water (Neth.), **34**:95 ('50). Luxembourg has pop. of 291,000 residing in 2 different regions—one, "Ardenne," with area of 824 sq.km., has density of 43 people per sq.km.; other, "Bon-Pays," with area of 1758 sq.km., has density of 145. Ardenne hilly and Bon-Pays rolling country. Climate mild with southwest winds predominating and avg. rainfall of about 37″ fairly evenly distributed over year. Principal river is Meuse with its tributaries. Geological formations in 2 areas entirely different. In Ardenne, hills formed by argillosilica or silicon rock, dense, with absorption on order of 1%, and consequently little storage of water. Hence,

(*Continued on page 46*)

Treat your plant to these advantages...

clearer effluent
•
greater capacity
•
lowest cost

with

REX

Floctrols
•
Verti-Flo Clarifiers
•
Flash Mixers

Ashland, Oregon Water Filtration Plant employing 2 Rex Flash Mixers; 2 Rex three-stage Floctrols; 2 Rex Verti-Flo settling tanks, each equipped with Rex Conveyor Sludge Collectors. Plant Capacity—6 MGD.

Where you want *real* results from your water treatment plants... clearer effluent... maximum capacity at minimum cost in new or existing installations, check Rex Clarification Equipment.

REX FLASH MIXERS effect almost instantaneous dispersion of chemical throughout the water. Installed in small tanks immediately preceding flocculation tanks, they provide an exclusive double mixing action. Slow rotation is combined with fast top-to-bottom turnover for most thorough mixing.

REX FLOCTROLS are low in initial cost and cut chemical requirements to the minimum. Properly proportioned, scientifically designed paddles ... rotating baffles ... fixed partition walls with center ports ... are so arranged that thorough mixing is assured and short circuiting eliminated. Fast tapered mixing by zones assures large, readily settleable floc.

REX VERTI-FLO CLARIFIERS deliver a highly clarified effluent with an extremely short detention time. A series of adjustable weirs and baffles divide a rectangular settling tank into a series of cells. Close distribution of flow among the cells is accomplished by adjusting the weirs. A combination of large weir length and low vertical velocities assures a clearer effluent, far greater capacity ... minimum cost.

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Company.....
Address.....
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(Continued from page 44)

ground water must be obtained in Bon-Pays area, where conditions for ground water storage much better. Chem. compn. of water in 4 principal aquifers:

Substance	Bigarre Sandstone	Coquillier Limestone	Supralias Sandstone	Luxembourg Sandstone
	ppm.			
Total hardness	489	770	182	233
Temporary	340	370	145	205
Permanent	149	400	37	28
Total solids	614	1015	226	282
Ca	126	179	67	88
Mg	43	79	4	3
SO_4	116	307	34	24
Cl	25	11	10	8
NO_3	24	3	8	14
HCO_3	415	451	177	250

First considered relatively hard, second hard and 2 others soft, with pH values of about 7.5. Coliform organisms absent and total bact. counts rarely over 10 per ml. Water distr. systems comparatively recent; oldest in city of Luxembourg, put in service in 1866; that for city of Esch installed in 1885. Difficulties in collection and distr.: [1] country not rich enough to build large reservoirs, [2] certain rock formations and outcroppings subject to poln., [3] best water source (Luxembourg sandstone) too low for gravity distr., [4] priority rights of city of Luxembourg. Water supplies controlled by syndicates consisting of groups of communities. Syndicate or individual communities may own local distr. systems. "Superior council" coordinates and regulates various services, handles admin. and tech. problems, sets stds. and controls periodically through inspectors and anals. with aid of ministry of public health. For new construction, state may contribute 10–50% of costs. Water distributed in 131 communities, serving

(Continued on page 50)

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Sioux Falls Adds Horton Tank

This 750,000-gal. radial-cone bottom tank has been added to the water distribution system of Sioux Falls, S. D. The new tank is 81 ft. to the bottom and will provide a supply of gravity water to improve pressures in the mains throughout the city. Write our nearest office for estimates on elevated tanks or reservoirs when planning waterworks improvements.

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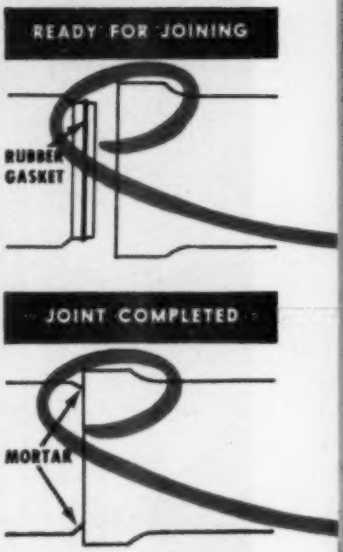
PRESTRESSED CONCRETE STEEL-CYLINDER PIPE

Longest trouble-free service at lowest cost

Prestressed Pipe combines the strength of steel, the protection of concrete and the flexibility of a rubber joint to provide *a combination of advantages found in no other pipe.* It has a life expectancy of 100 years and more, highest carrying capacity, and water tightness under highest pressures. Its great structural strength provides safety from sudden and complete failure. It is easy to lay, easy to tap, and provides great flexibility in design.

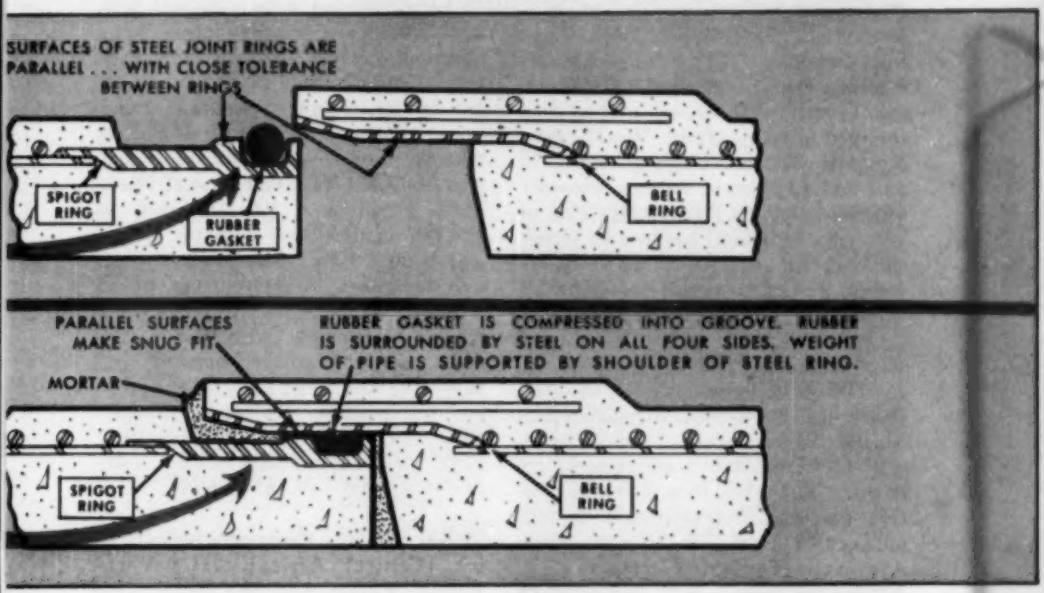
Prestressed Concrete Steel-Cylinder Pipe is available in 16 foot lengths and in the following diameters: 16″, 20″, 24″, 30″, 36″, 42″, 48″ and larger.



Price Brothers engineers know pipe line design and construction problems. We will be glad to estimate pipe and installation costs, without obligation.

Installing Price Brothers Prestressed Pipe on the 80-mile Saginaw-Midland project, one of America's longest high-pressure water supply pipe lines. Pull shovel lays pipe and pushes joint together.

This rubber and steel joint has proven highly successful in high-pressure water lines. The spigot ring fits snugly inside the steel bell ring of the adjoining pipe. A special composition rubber gasket, recessed in the spigot ring, is tightly compressed between the two rings. When joint is completed, the gasket is surrounded on all four sides by zinc-coated steel. The rubber gasket maintains a flexible connection that permits the pipe to adjust to expansion, contraction, vibration, and external loads without leakage. Mortar is applied to the joint after pipe is laid.


SURFACES OF STEEL JOINT RINGS ARE PARALLEL . . . WITH CLOSE TOLERANCE BETWEEN RINGS
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RUBBER GASKET
BELL RING
PARALLEL SURFACES MAKE SNUG FIT
RUBBER GASKET IS COMPRESSED INTO GROOVE. RUBBER IS SURROUNDED BY STEEL ON ALL FOUR SIDES. WEIGHT OF PIPE IS SUPPORTED BY SHOULDER OF STEEL RING.
MORTAR
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BELL RING

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_____

(Continued from page 46)

277,000 (95%) population; consumption about 125 l. per capita. New syndicates contemplated to serve 14,000 people now without public water supply. Description of distr. systems, storage reservoirs and pumping stations given.—*Willem Rudolfs.*

Sydney's Water Supply [Australia]. H. BOWDEN FLETCHER. Wtr. & Wtr. Eng. (Gt. Br.), **53**:57 (Feb. '50). Plan embodies: [1] erection of Warragamba Dam to impound 460,000 mil. gal. (Imp.); [2] constr. of new and enlarged pipeline from Warragamba Pumping Sta. to Prospect Res., 17 mi.; and [3] constr. of new pressure tunnel from Potts Hill Storage Res. to Waterloo, 10.4 mi. Number of minor amplification schemes included. Warragamba Dam largest impounding scheme in Southern Hemisphere. Cost will approach £9,000,000. Model construction town built at remote site for 600 families in cottages and 800 single men in barracks at cost of £1,000,000. Dam straight gravity type, wall 420′ high, 360′ wide at base, 30′ at crest, and 1350′ long. Comprehensive geological investigation at site included 4′-diam. shafts, 200′ deep. Avg. daily flow of Warragamba R. 500 mil.gal. (Imp.) with watershed of 3383 sq.mi. Flood waters will pass over crest of dam at estd. max. of 500,000 cfs. Energy of this wall of water, 40′ high, will be dissipated in hydr. jump on concrete apron full width of spillway and extending 300′ downstream from toe. 2,800,000 tons sand and gravel, required for 1,750,000 cu.yd. concrete, will come 12.3 mi. on cableway from borrow pit. Concrete to be centrally mixed at 2 cu.yd./sec. During summer bulk of concrete will be mixed with crushed ice made by 200-ton ice plant. Chilled water will be pumped through 1″ pipes in concrete. Warragamba-Prospect pipeline will be increased to total capac. of 120 mgd. (Imp.) by constr. of 106″ main for 2.6 mi. to Nepean R. crossing, and 84″ main thence 14.5 mi. to Prospect. Both sections located parallel to existing 48″ main. Completed tunneling for 106″ main done by compressed-air rock drills and firing whole face. 106″ steel liners in 10′ lengths lined with 2″ centrifugally spun mortar and have spherical ball-and-socket ends to permit adjoining liners to overlap and weld together. Rate of lining 10′-wide tunnel was 10′ per day. City tunnel comprises 2 sections; upstream section of 27,542′ to take 96″ liners, and downstream section of 27,404′ to take 84″ steel liners. Max. grade is 1:100 and min. is 1:2000. Tunnel will care for all demands until 1985 when booster pumps may be added. Ventilation of tunnel provided by fans with 25- or 30-hp. motors to exhaust through 20″-diam. ducts. Normal working team at each shaft 25, with most modern amenities and conveniences provided. Completion now scheduled for mid 1952. Total cost of threefold scheme estd. at £16,500,000.—*H. E. Babbitt.*

Water Supply: Resources and Quality [Central Africa]. H. WALLHOUSE. Central African Council. Native Housing: Tech. Paper No. 5 (Apr. 21, '49). Amt. and qual. of water important to functions of colonial administrator. This paper of particular interest to engineers dealing with water supply problems. Paper contains engineering formulas which will be of greater interest to civil engineer than medical officer. Purity of supply of first importance and author stresses necessity of making adequate survey before any works commence, and of noting any potential sources of poln. Drainage of all buildings within catchment area must be investigated and agricultural land checked for its manurial content. Importance

(Continued on page 52)

10?
30?
20?
40?

50 IS LUCKY

..on a water line job

It's not numerology—just plain economics.

Consider how 50-foot lengths of Armco Welded Steel Pipe "shorten" any water supply or force main. There are fewer joints (just 106 to the mile) and less assembly work. Labor time is cut—job costs drop to the bottom.

You'll like this too: Armco Pipe is light in weight for easy handling. Accurately machined pipe ends simplify and speed field connections.

But that's not all. Armco Welded Steel Pipe is amply strong with a high safety factor against internal and external pressures. A spun enamel lining assures continued high flow capacity, prevents tuberculation, stops costly cleaning.

Diameters of Armco Pipe range from 6 to 36 inches with wall thicknesses from ¼- to ½-inch. You can match job requirements exactly. Write for more information. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4000 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation.

ARMCO WELDED STEEL PIPE

ARMCO

(*Continued from page 50*)

of bact. examn. emphasized. Paper useful contribution to literature of tropical water supplies and should be read by all engineers engaged in this work.—*B.H.*

Water Supply and Drainage Committee's Report [Madras, India]. T. T. KRISHNAMACHARI ET AL. People's Health (Madras, India) **2**:283 (Mar. '48). Extensive report on improvement of all phases of water supply, drainage and sewage disposal in Madras thoroughly discussed and criticized by group of lay and professional authorities. Number of pertinent editorials and other press releases presented. Report contains 39 sections devoted to complete reorganization and extension of all aspects of rural and urban water supplies and drainage.—*P.H.E.A.*

The Construction of New Water and Sewerage Systems in the Mexican Republic. MANUEL ANAYA Y S. Bol. Oficina Sanit. Panamer., **27**:310 (Apr. '48). Acct. of water supply and sewage factors in public health in Mexico and government progress in extending such systems. Due to extensive implications of program, office of hydr. resources created under san. eng. services of Mexico's federal government. During year U.S. Office of Inter-American Cooperation for Public Health responsible for 7 water supply and 6 sewerage systems operating and 15 water supply and 6 sewerage systems under constr. in 16 communities. Eighteen water supply systems and 19 sewerage systems in planning stage. In addn., Mexican government plans to construct during 1948 95 water supply systems and 6 sewerage systems in 99 communities, with pop. of more than 1,000,000 being served.—*P.H.E.A.*

ANNUAL REPORTS

Montgomery (Ala.) Water Works Board. Official Statement Relating to the Issuance of $2,200,000 Water System Revenue Bonds (Feb. 8, '50). Issue of $2,750,000 (3%) authorized to provide funds for extensions and improvements, reimbursement of city for improvements already made, sinking fund for existing city bonds assumed by board and working capital; $550,000 bonds reserved for subsequent issue as funds required. Estd. principal and interest charges on all obligations to '73 $11,368,536.25. Water Works Board created in Oct. '49, in accordance with Code of Alabama, to acquire and operate water system maintd. and operated by city. As part of compensation therefor, board agreed to pay city fixed charge of $12,000/yr. Terms of purchase included payment to city of $780,000 cash and assump-

(*Continued on page 54*)

SUBMERGED PIPE LINE CONSTRUCTION

BOYCE COMPANY

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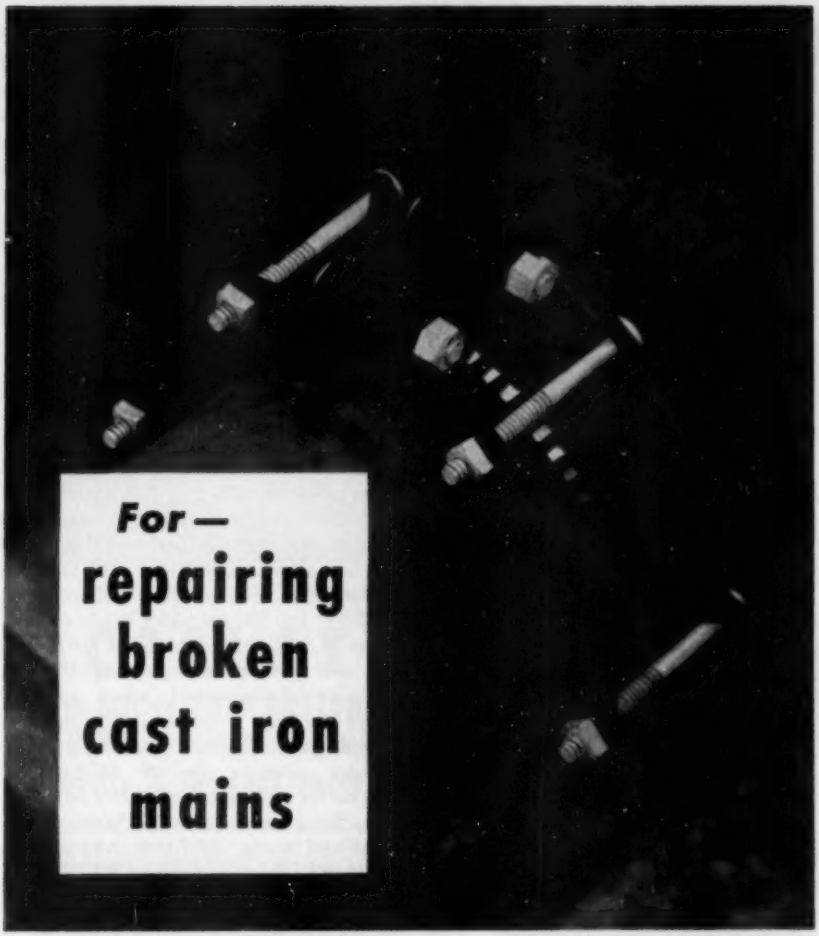

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Insures against recurrence of trouble by introducing a degree of flexibility in the line. Each clamp tests to 800 pounds line pressure. Sizes 2"-24" inclusive. Be prepared — order today.

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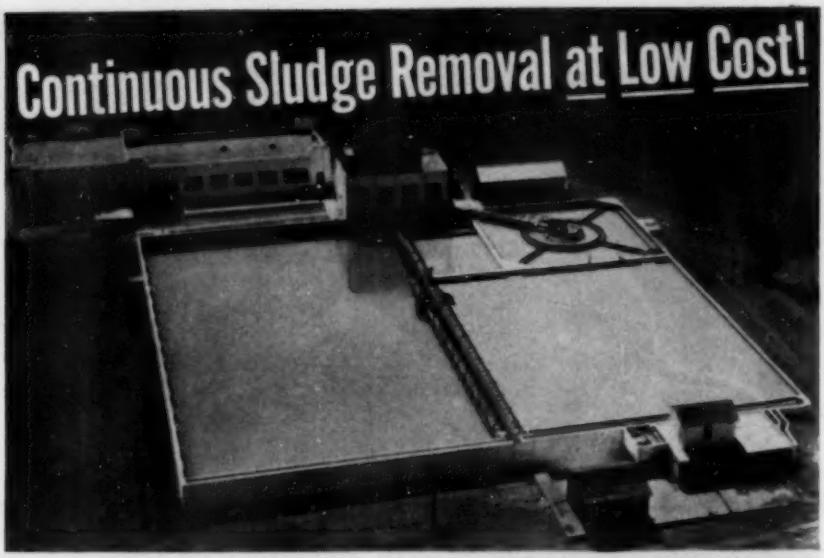
(*Continued from page 52*)

tion of outstanding bonds ($5,316,000). *Report on System.* Supply from 2 well fields. Court St. Station comprises 31 wells, 100′–600′ deep, 16 operated by elec. deep well pumps and 15 by air lift. Dependable capac. of former 6.5 mgd., increased to 8–9 mgd. by air lift wells for 2 days, thereafter falling to 6.5 due to lowering of water table. Wells discharge into ground level reservoirs, total capac. 7 mil.gal., hence pumped into distr. system by elec. centrifugals, with steam standby. Day St. Sta. comprises 15 gravel wall wells 200′–600′ deep, 10.8-mgd. capac., elec. deep well pumps. Aerated and discharged into 2 concrete reservoirs, total capac. 4 mil.gal., thence into distr. sys. by elec. centrifugals. Raw water supply from Alabama R., consisting of 12″ intake, 2 deep well pumps and 0.5-mil.gal. standpipe, entirely separate from domestic system, delivers 20 mil.gal./mo. to 2 railroads. Court St. supply soft and practically free from Fe and CO_2, treated with Cl only. Day St. supply contains 0.15–1.1 ppm. Fe and 2–28 ppm. CO_2 and causes red water complaints. Tests indicate Fe derived from first 200′ depth, which can be sealed off. Avg. consumption increased from 6.3 mgd. in '40 to 10.6 in '48 and max. from 9.4 to 15. Services increased from 16,200 to 22,742 in '49. Five addnl. wells would provide for estd. max. demand to '55. Water entering water-bearing formation far exceeds estd. future requirements if wells spaced properly. Present spacing at Day St. Sta. 1000′, apparently conservative. Extension must be confined to Day St., as further supply from Court St. impracticable. Addnl. storage at former advisable. Only other source Alabama R., which would require treatment at estd. cost greater than present costs. Elev. storage, 1 tank and 2 standpipes, total capac. 2.076 mil.gal., adequate. Distr. sys. improvements necessary total $690,062. Several methods considered for correction of Fe problem, including sealing off Fe-bearing water, abandonment of offending wells, and Fe removal by aeration or contact beds and filtration. Total constr. necessary during next several years $1,511,500. In addn. to constr. suggested in above report, board contemplates 100% metering, monthly machine billing and other improvements to be financed from bond issue. New rate schedule: min. monthly charge $1.50 and $0.75, with and without sanitary sewers, respectively, for 4333 and 2167 gal., respectively, and 35¢ per 1000 gal. for first 25,000 gal., decreasing to 12¢ for over 350,000 gal. Min. monthly charge varies with size of meter and allows use such charge would pay for under above schedule. Private fire protection: $40/yr. for hydrants and $25/yr. for 500 sprinkler heads or less, plus 5¢ for each addnl. head. All public and private users charged alike. Service discontinued when bill 30 days overdue. Annual public fire hydrant rental $75 (1507 hydrants). Water revenue in '49 $676,059.18, operation and maint. $269,698.34. Est. for '50: gross revenue $975,000, operation and maint. $297,000, debt service $431,688, reserve funds $201,750, excess revenue $44,562. One provision of indenture establishment of gross earnings reserve fund into which 7% of gross paid, funds accumulated therein to extent not required to make up deficiency in operating reserve being paid semiannually to city. Estd. pop. 120,000 within city, in metropolitan area more than double that.—*R. E. Thompson.*

East Bay Municipal Utility District, Oakland (Calif.). Annual Report (Year Ending June 30, 1949). Second Mokelumne Aqueduct completed within $21,700,000 cost est., increasing ultimate supply from Mokelumne Sys-

(*Continued on page 58*)

Continuous Sludge Removal at Low Cost!



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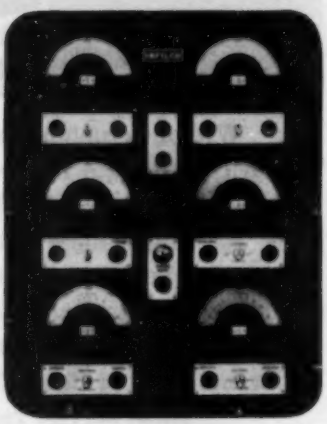

An ACCELATOR only *70 feet square* softens and clarifies 50% more river water for Muskogee, Okla., as the former method did in a space 210 feet square! Extreme flexibility of operation with a remote push button filter control system centralized on one panel, is a feature of this highly satisfactory installation. The flow through all filters is maintained at a uniform rate and increased or decreased as desired by simply pressing the proper button!

ACCELATORS invariably give simpler operation, faster chemical reaction, higher ratings and an exclusive slurry recirculating feature which produces better, clearer water in less time. They can effect up to *80% savings in space!* Mixing, coagulating, settling, and sludge removal . . . *all* these operations are replaced in ONE COMPACT UNIT! ACCELATOR installations are now economically treating over *One Billion* Gallons of water daily. Get all the facts. Send for our new 28 page bulletin No. 1825. Write today!

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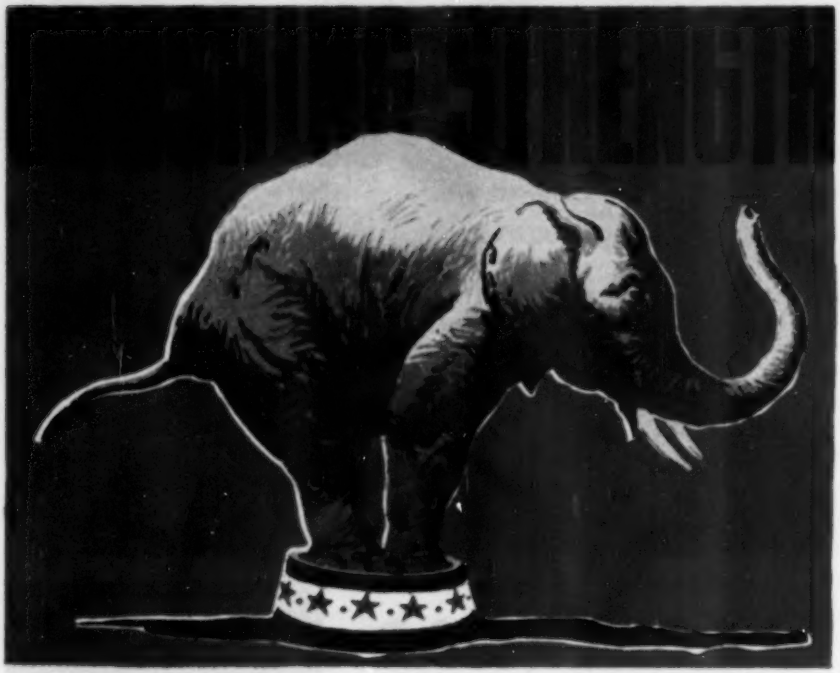


____ Without crushing strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today.

But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada.

Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety.

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets.

Cast Iron Pipe Research Association,
Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON PIPE

Strength factors of Long Life !

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

CRUSHING STRENGTH

The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH

When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

SHOCK STRENGTH

The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times *on the same spot* from progressively increased heights of 6 inches.

BURSTING STRENGTH

In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

SERVES FOR CENTURIES

(*Continued from page 54*)

tem 125%. Services approx. 200,000, serving more than 900,000 pop. in 10 cities. Avg. consumption 111 mgd., max. 163. System includes Pardee Res. on Mokelumne R., 93-mi. steel and concrete aqueduct, 2 large pumping plants and Lafayette Dam, local terminal reservoir. Distr. sys. of East Bay Water Co. purchased in '29. Up to '40, tax and water rates declined steadily. During war, pop. increased from 525,000 to 900,000 and consumption from 45 to 107 mgd., necessitating second pipeline. Latter delivers more than 50 mgd. by gravity, can be increased to 110 by adding 2 pumping plants, giving total capac. of 200 mgd. Meters 201,919, increase of 7143. More than $13,000,000 expended during year for new facilities. In excess of 85 mi. new mains constructed and storage capac. increased as much as 500% in some areas. Value of plant property and equip., after deducting $24,549,451 depreciation reserve, $102,249,666, total assets $111,395,598, bonded debt $53,625,000, taxpayers' equity $52,053,697. Operating income $10,806,007, operating expense $5,212,382, bonded debt service $2,134,875, excess of income over expenses $3,254,853, proceeds of taxation $1,299,685, increase in taxpayers' equity $4,783,263, bonds retired $2,115,000.—*R. E. Thompson.*

Des Moines (Iowa) Water Works. Annual Report (1949). Consumption 20.43 mgd., 107.4 gpd./cap., 81.8% metered. Return 27¢ per 1000 gal. billed. Services 45,404, 99.6% metered. Mains 460.9 mi., pressure 38–118 psi., hydrants 3929 (rental $10.95). Gross income $1,648,621.64, per cap. $8.67, per mil.gal. pumped $221.07. Net income, exclusive of fixed charges and depreciation, $1,052,761.63, per cap. $5.53, per mil.gal. pumped $141.17. Operating cost, exclusive of fixed charges and depreciation, $595,860.01, per cap. $3.13, per mil.gal. pumped $79.90. Interest 8.41% of gross income, net balance $535,594.12. Paid-for plant, property and addns. $9,525,056.08, depreciation $3,287,747.01, book value $9,716,146.30, bonded indebtedness $3,251,000. Coal per 1000 gal. pumped 3.34 lb., boiler and stoker eff. 70.5%, coal cost per 1000 lb. water evapd. 39.84¢, overall thermal eff. 9.84%. Avg. water compn. (ppm.): Ca 83.2, Mg 26.1, mineral residue 406, free CO_2 24, residual Cl 0.31, Fe 0.14, alky. 215, D.O. 2.2, pH 7.4. Cl dosage 1.07 ppm. Bact. counts, 37°C., 1 ml.: at pumping station 1.43, office tap 2.30, Allen Hazen Tower 1.21. Coliform tests at these points all neg. Of 1925 samples from distr. sys., 80 pos. in presumptive test for coliforms and 15 confirmed in B.G.B. Water softening plant placed in operation Dec. 7, '49. Avg. monthly hardness Jan.–Nov. 281–316 ppm. (max. 345), Dec. 148.—*R. E. Thompson.*

Grand Rapids (Mich.) Annual Report (Year Ending June 30, 1949). Pop. served 200,000, consumption nearly 11 bil.gal., 172 gpd./cap. Meters 43,000, read quarterly. Bonds retired from water revenue $185,000. Outstanding water works bonds $1,800,000.—*R. E. Thompson.*

Scarsdale (N.Y.) Annual Report (1948–49). Estd. pop. 14,500. Supply from L. Pocantico, belonging to New Rochelle Water Co., and from Bronx Pipeline and Catskill Aqueduct. Croton Aqueduct water also available. Pipelines 85.7 mi., hydrants 767, meters 3760, meters reconditioned 690, pumping stations 2, standpipes 2. Rates $2.05 per 1000 cu.ft. (in first block—great majority of users) with service charge of 50¢ per quarter for ¾" meter. Water bonds outstanding $250,000. Avg. daily consumption 1.72

(*Continued on page 60*)

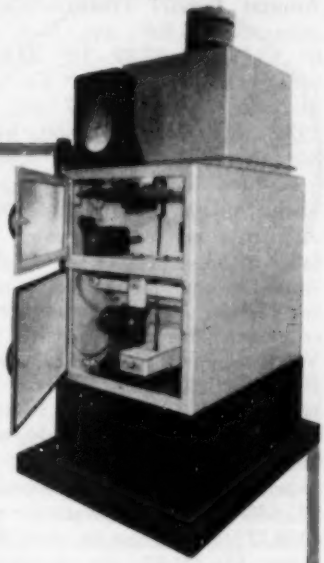
It's the "LAST WORD"!

OMEGA

Gravimetric Fluoridizer

. . . the last word in dry feeders

for Sodium Fluoride



It's new, it's accurate, it's safe! The **Omega Gravimetric Fluoridizer** with the non-flood feeding mechanism sets a new high in automatic feeding of Sodium Fluoride. Municipal tooth decay control programs keep to the "straight and narrow" with this extremely accurate loss-in-weight type Gravimetric Feeder. The maximum feeding rate is pre-set at the factory for each fluoridation requirement. Flooding or serious over-feeding are physically impossible. The **Gravimetric Fluoridizer** incorporates sentinel alarms to warn of under-feeding . . . and totalizers to give a positive pound-by-pound check on chemical actually delivered. For complete information and new Bulletins 30-G1 and 50-64, address Omega Machine Company (Division of Builders Iron Foundry), 365 Harris Ave., Providence 1, R. I.

Gravimetric Fluoridizer includes the new Rotatrol which converts oscillating motion to rotary motion . . . drives the flood-proof Rotolock at proper rate to fulfill the Sodium Fluoride demand.

OMEGA PRODUCTS

Belt-Type Gravimetric Feeders
Loss-in-Weight Gravimetric Feeders
Universal Feeders
Precision Solution Feeders
Disc Feeders
Rotodip Solution Feeders
Rotolock Feeders
Lime Slakers
Laboratory Stirrers
Dust Collectors
Chemical Elevators

THE LAST WORD IN FEEDERS

OMEGA

(Continued from page 58)

mgd., leakage and unmetered use 13.7%. Plant and equip. at cost $1,631,980.23, total assets $1,828,194.48. Village equity $1,562,689.76, increase of $51,383.79 during yr. Water sales $157,508.59, fire protection and hydrant rental $38,768.68, total revenue $200,621.32, operating expense $138,483.37, interest $12,208.32, bond redemption $40,750, capital outlays $7698.40, balance $1481.23.—*R. E. Thompson.*

Green Bay (Wis.) Water Dept. Annual Report (1949). Cast-iron mains laid 20,308′; avg. costs per ft., 6″ $3.71, 8″ $5.39, 10″ $4.01, 12″ $7.07. Avg. cost of ¾″ Cu services $1.21/ft. Services 69.7 mi., mains 147.7 mi., meters, 12,460, hydrants 848. Pumpage: max. 8.5 mgd., avg. 5.5 (7.8% increase), 103.6 gpd./cap. Kwhr./mil.gal. at 8 wells 2650–3543. Avg. costs per mil.gal.: power $36.72, labor $7.85, total $44.57. Water delivered through meters 86.2%, unacctd. for 13.3%. Meters repaired 699; avg. cost per meter in service 22.6¢. Works acquired Nov. 1, '20, for $999,750.70, total bond issue $975,000, bonds retired $451,000, bonds outstanding $524,000. Operating revenue $336,250.13, total revenue $338,916.55, expenses $164,615.03, depreciation, $35,530.43, net operating revenue $138,771.09, interest on debt $33,090, taxes $54,234.93, net income $51,446.16, return on city equity paid to city $6,000, surplus to date $772,747.45. Assets: plant $2,628,609.20, bond and interest redemption fund $35,039.89, total assets $2,727,473.46. City equity $100,000, depreciation reserve $611,489.84. All water chlorinated.—*R. E. Thompson.*

Report of Chief Engineer, Liverpool (Gt. Br.) Water Works (Year Ending March 31, 1949). Water derived from Vyrnwy, Rivington and wells—13,823, 5325 and 1032 mil.gal. respectively; total 20,180 mgd., 2.2% decrease. Rainfall on Vyrnwy gathering ground 88.9″, Rivington 48.45″. Avg. consumption 55.44 mgd., decrease of 1.25, max. day 61.83. Hydrants 22,355. Water tenants 313,073. Filtration of Vyrnwy water at Oswestry: filters 23, sand area 18.9 acres, avg. no. of cleanings each filter 7.47, avg. water filtered 37.93 mgd. (equiv. to 2.286 mgd. or depth of 4.198″ water passing through filter medium per hr.), avg. filtered per acre between cleanings 111.71 mil.gal. Filtration of Rivington water: filters 8, sand area 5.84 acres, avg. no. cleanings 11.75, avg. water filtered 13.15 mgd. (equiv. to 2.6 mgd. or 4.77″ vertical per hr.), avg. filtered per acre between cleanings 80.766 mil.gal. In '41, Kensington Res. No. 2 damaged in air raid, 800-sq.yd. roof, columns, etc., destroyed—repaired temporarily at time and permanent repairs now under way at cost of £7,838. Activities in Vyrnwy area include forestation and wood cutting, farming and sheep raising. New works included repair and lining of Hirant Tunnel from L. Vyrnwy, 7′ diam. and 3842 yd. long, of which only 682 yd. originally lined; addns. to Vyrnwy aqueduct; supply main to Chorley; 174-mil.gal. Prescott No. 4 Res.; and elec. pumping plant to replace steam pumps at Green Lane. Avg. water qual., in ppm., for Rivington, Vyrnwy, Green Lane well, Dudlow Lane well, respectively: dissolved solids 83.4, 35.6, 428.9, 233.2; hardness 31.4, 11.2, 283.4, 110.5; pH 4.9, 6.3, 7.0, 5.9. Of 826 samples from various supplies examd. for *Esch. coli*, 819 neg. in 100 ml., 6 pos. in 100 ml., 1 pos. in 90 ml. All portions of 80 ml. or less neg. Rates: domestic water rent in city 11.5*d.* in the £, in outtownships 1*s.* 5.5*d.* Statutory fixed water rate of 6*d.* in the £ charged against all premises assessed for general rate purposes in city. Trade supplies by meter 11.5*d.* per 1000 gal.,

(Continued on page 62)

● It isn't necessary to specify oversized pipe for your large-diameter water lines to meet anticipated "shrinkage" in flow capacity due to tuberculation.

It's far less expensive to *prevent tuberculation* by coating the pipe interior with a glass-smooth spun lining of Koppers Bitumastic® 70-B Enamel. Then you can select pipe size solely on the basis of desired capacity.

And Bitumastic gives you a lastingly-high coefficient of flow that reduces pumping costs . . . results in savings that more than pay the cost of the lining.

Koppers Bitumastic 70-B Enamel also makes it unnecessary for you to specify additional wall thickness to compensate for corrosion. An exterior coating of Bitumastic 70-B Enamel, combined with the spun lining, forms a barrier against all types of corrosion, inside the pipe and out.

Make certain your community is getting its money's worth of proper protection—specify Koppers Bitumastic 70-B Enamel for your large-diameter lines.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC., Tar Products Division, Dept. 805T, Pittsburgh 19, Pa.

(Continued from page 60)

supplies to shipping 1*s.* 9*d.* Capital expenditures to date £9,820,273. Income £1,005,139, expenditures £948,-023. Of latter, £360,197 loan charges. ——*R. E. Thompson.*

ORGANIZATION AND ADMINISTRATION

Water Works Organization: The Problem of Size. DELWYN G. DAVIES. Abstract of paper presented at Inst. of Water Engrs. meeting, Mar. 17, '50. Wtr. & Wtr. Eng. (Gt. Br.), **53**:221 (May '50). During recent years there has been considerable thought in both Britain and America concerning influence of size of organization on indus. eff. and human relations. Difficulties which go with increased size and specialization familiar. Existence and nature of relationships between size and human interest, frustration and total eff. should be examd. As organization grows, duties and powers of management increase, operational jobs of workers tend to diminish in responsibility and interest. Strength and eff. of unit depends not only on man at top but on liveliness of whole organization. Permanent conflict exists between tech. eff. of great size and its human deficiencies. Lower economic limit for operational size of water works enterprise about 70,000 pop. for rural area. Top limit about 700,000. Far too many small water enterprises exist which should be amalgamated into units of adequate size. If water supply to be nationalized, grouping of about 15 semiautonomous units into region with pop. of nearly 3,000,000 would enable 6 needs to be satisfied: [1] economic, tech. and social comparisons between one unit and another and their predecessors; [2] provision of medium-sized semiautonomous units and their consequent tech. and social advantages; [3] supply of specialist skill at center to advise units when required; [4] efficient economy of resources and bulk purchases; [5] better balance between ability, duty, authority and responsibility; and [6] gradualism in transition from present pattern of water works. Unitary system, which provides means of comparison between units, far superior to wholesale functionalism, where one expert on, say, filtration, has authority over all regional filtration personnel, for which unit administrators held responsible. Organization strengthened if regional specialized advice available should it be desired. Difficulty does exist in achieving this goal without impairing democratic control. Through improved knowledge of management, range of min. and max. operational sizes may be extended upward in future, but until that time medium-size operational unit possesses considerable advantages over extreme sizes.—*H. E. Babbitt.*

Regionalization of Water Supplies. Discussion at Joint Meeting of Royal Sanitary Institute and Institution of Water Engineers. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **53**:166 (Apr. '50). There is optimum size for water works. If too small, revenue likely to be insufficient for qualified staff. If too large, tends to become departmentalized with loss of eff. Except for large cities, best size has following qualifications: [1] income sufficient to allow employment of qualified staff; [2] engineer of water works should be able directly to supervise daily working; and [3] authority should be able to find sources of supply within own boundaries. Analogy with elec. supply not proper. For water supply, size of station detd. by capac. at any one source to supply more than certain quant. and, there is, therefore, definite limit to reduction of number of sources. Argument for regionalization is that it reduces competition

(Continued on page 64)

More than a Million LUDLOW HYDRANTS are Landmarks of Security!

Simplified Servicing without digging

To inspect or service a Ludlow Slide Gate Hydrant you'll need a wrench—that's all. Just take off the top of the hydrant and lift out the stem, *without unscrewing anything below ground.* The entire mechanism, including the gate, bronze wedge nut and drip assembly is attached to the stem.

LUDLOW FIRE HYDRANTS

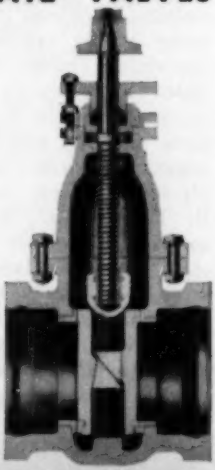
Shown here is the distinctive Ludlow List No. 90, now serving in thousands of cities and towns. It employs the famous Ludlow Slide Gate principle, and (in addition to easy servicing) offers the following advantages:

- ***Quick Water*** **with least possible shock and pressure loss. Proper shut-off without water hammer.**
- ***Proper Drainage,*** **automatically, at lowest point when closed.**
- ***No Flooding.*** **Wedge-locked when closed. Accidental breaking will not cause flood. Hydrant head breaks at ground line — is easily replaced without excavation.**

LUDLOW AWWA DOUBLE DISC GATE VALVES

The parallel seated, double wedge type slide gate valve, developed and perfected by Ludlow, provides a number of essential benefits.

- ***Smooth, Positive Operation.*** **Gates positioned directly opposite ports before wedging, and entirely unwedged before being raised.**
- ***Positive Closure.*** **Even after years of service in the open position; flexible-action gates self-adjusting to seats.**
- ***Simplicity!*** **Only 2 parts in the wedging mechanism! These are extra heavy with ample reserve strength and wear resistance for years of constant service.**



Made in sizes from 2" to 72", N.R.S. and O.S.&Y. with all types of connections. 95-S

TRADE LUDLOW MARK

The LUDLOW VALVE MFG·CO·INC·TROY·N·Y· SINCE 1866

(*Continued from page 62*)

between water works for new sources of supply in areas where sources limited. Centralization of control by grouping of authorities facilitates long-term planning over reasonably wide area. Regionalization affords means of elimg. inefficient water works authorities. Emphasis on need for extending piped supplies in rural areas, cost being spread by grouping areas where such schemes would be beyond resources of rural area concerned. Improved means of communication makes possible admin. of larger areas of supply than formerly. Economies due to unification of staff, pooling of spares, stores and transport, and bulk purchase of materials could be effected. Regionalization is means of standardizing water rates over larger areas. L. F. HOBBS regarded min. size of water works as one supplying between 50,000 and 100,000. Region is unit made up of number of operating works of reasonable size, coordinated by joint advisory water committee. By far cheapest and most efficient way of supplying community is from local resources. England probably has finest water supply organization in world and should change it as little as possible. S. H. DE LA MARE: It seems no one's concern to prevent wastage from taps and services. There is no organization with regard to water supply such as in gas and elec. industries. B. T. BALDOCK: Water Power Resources Committee Report in '21 showed that England could not have large distr. units because it would have to decentralize. Although tech. progress in water supply second to none in world England has fallen behind somewhat in respect to control of supplies. Follows that distr. units must be smaller than some of big works of today. M. MACKENZIE: Rural supplies, due to baths, lavatories and so on, yield contmd. effluent which must be dealt with. Government cannot propose to proceed with nationalization of water supply and neglect sewage disposal. E. J. BAXTER: Regionalization has worked where there were voluntary regional committees. Essential for all water works to have access to best advice, whether financial or tech.—*H. E. Babbitt.*

The Water Supply Industry—Case Against Nationalization. EVELYN HULBERT-POWELL. Wtr. & Wtr. Eng. (Gt. Br.), **53**:25 (Jan. '50). Reprinted from *Soundings*, Nov. '49. Growth and development of public water supply in England has long history. New River Water Scheme one of earliest in London, established in 1613. In present century demand for water increased greatly. Rural Water Supplies Act, 1934, made £1,000,000 available from treasury in grants to provide piped water supplies in rural areas. Central Advisory Water Committee constituted in '37 began drafting of bill to modernize and consolidate into single measure existing general acts. World War II prevented bill from reaching statute books. In '44 another White Paper entitled "A National Water Policy" presented to Parliament. Passage of Water Act, 1945, implemented recommended changes. Act gives water undertakers power to acquire land and execute works for protection of water, to supply water and raise capital. Act contains new "Water Code." Nationalizers make no reference to provisions and powers given under Water Act. Folly of resorting to costly expts. of nationalization of water supplies should be plain to all. All powers of central control required by nationalizers or anyone else exist already. In Scotland, case against proposed wanton action by nationalizers even stronger. In May '49 Scotland Water Act became law. This act contains all necessary powers. With re-

(*Continued on page 66*)

CARLON

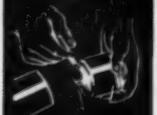
The first real pipe that is plastic!

Corrosionproof

Light weight

Flexible

Long Life



Ease of Installation

CARLON PLASTIC PIPE combines the features of flexibility, light weight, absolute corrosion resistance, and long service life to become the outstanding development in the field of fluid transmission.

CARLON pipe can be curved to follow a ditch line or ground contour. Its extreme light weight facilitates rapid, low-cost handling from time of manufacture to installation.

Because of its resistance to rot, rust, and electrolytic corrosion, this remarkable new CARLON pipe has a projected service life many times longer than ordinary pipe, even under the most severely corrosive conditions. In addition, CARLON does not require heavy materials handling equipment for installation, and it eliminates the need for many fittings required by other types of pipe.

CARLON pipe is recommended for handling drinking water, transmitting sewage, and for land drainage and irrigation as well as other piping applications.

CARLON now is being striped to assure positive identification for the finest plastic pipe available today.

Specify the Pipe with the Stripe!

CARLON "EP" PIPE

NOM. PIPE SIZE	O.D.	I.D.	EST'D B.P. P.S.I.	WT. PER FT.	NORMAL SHPG. LENGTHS
½"	0.840	0.622	540	0.103	400 ft. coils
¾"	1.050	0.824	350	0.140	400 ft. coils
1"	1.310	1.070	200	0.181	300 ft. coils
1¼"	1.660	1.380	200	0.267	300 ft. coils
1½"	1.900	1.610	200	0.320	250 ft. coils
2"	2.378	2.070	170	0.445	200 ft. coils
2½"	2.875	2.469	170	0.68	200 ft. coils
3"	3.504	3.070	165	0.91	100 ft. coils
4"	4.504	4.030	150	1.25	25 ft. str.
6"	6.630	6.070	115	2.23	25 ft. str.

Identification Stripe: WHITE—Standard Pipe
RED —Heavy-duty Pipe

CARLON CP

CARTER PRODUCTS CORPORATION

10126 MEECH AVE., CLEVELAND 5, OHIO

(Continued from page 64)

spect to rural water supplies, nationalizers say that plenty of clean water essential for increasing quant. and qual. of milk supplies and modern methods of grass management require piped water supply. They are right that it is matter of importance but wrong in putting forward nationalization as way to increased piped water supplies for countryside. Rate of progress affords further evidence of failure to use existing powers. Nationalization proving notorious for increasing admin. costs and, worse, price of commodity to consumer. Recently reported that workers in state industries must wait until '53 for consideration by government of their claims to pensions. Water undertakers, on other hand, have generous superannuation schemes or *ex gratia* payments by way of pensions to retiring employees. Nationalization of existing water supply system cannot be in best interests of employees or community.—*H. E. Babbitt.*

Architectural Considerations of Water Works Structures. W. H. CUNLIFFE. Wtr. & Wtr. Eng. (Gt. Br.), **53**:161 (Apr. '50). Water works structures usually situated on open sites, prominent in landscape and often dominate vista of more-than-local beauty spot. Because of importance, such buildings often require architectural treatment. All too frequently architect called in when proportions already unalterable, and expected to clothe engineer's bare bones of structure with architectural flesh. Site of pumping station usually fixed by eng. considerations alone. Size and, to some extent, shape dictated by

(Continued on page 68)

For all types of Remote Valve Operation

LIMITORQUE

LimiTorque is widely used in Water Works

eliminates guess-work

"Push-button" operation of valves, with valve status indicated on control panels is the simplest, surest and safest method of opening and closing valves. Where valves are inaccessibly located, or where emergency may require positive operation from a remote area . . . the best solution is LimiTorque. Damage to stem, seat, disc, gate or plug is prevented in closing by the Torque Seating Switch which limits the torque and shuts off the motor before trouble occurs. Can be actuated by any available power source. May be obtained through your valve manufacturer.

Write for catalog on your Business Letterhead, please.

PHILADELPHIA GEAR WORKS, Inc.
ERIE AVENUE and G STREET, PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
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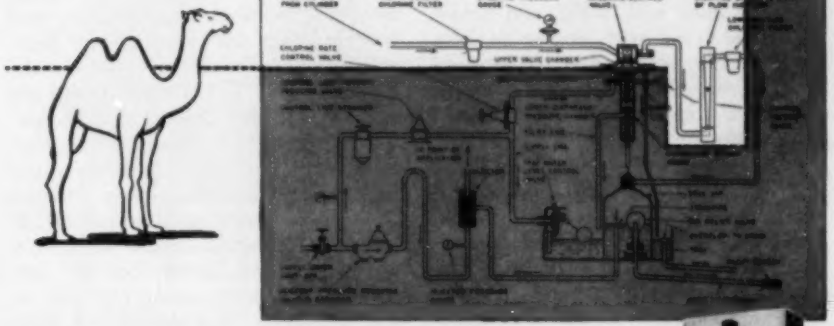
The DRY ZONE

MAKES THE BIG DIFFERENCE!

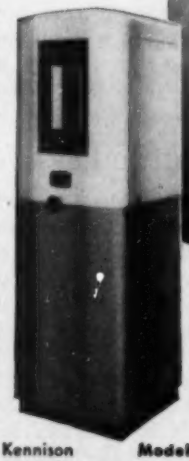


No wet chlorine in vital control parts

BUILDERS CHLORINIZERS control and meter chlorine gas in the dry, non-corrosive state. Dry, non-corrosive gas as it comes from the cylinder is regulated, controlled, and metered *before* it enters the bell jar where it first comes in contact with water. As a double protection, the chlorine control valve is lined with porcelain enamel and has a Tantalum diaphragm with silver valve seat and needle — materials that are completely unaffected by dry chlorine gas and highly resistant to moist chlorine gas.

Here is another of the many extra features of BUILDERS CHLORINIZERS. Be sure to get these features on your new and replacement chlorinators by specifying BUILDERS. For Bulletins and engineering information, address Builders-Providence, Inc. (Division of Builders Iron Foundry), 365 Harris Ave., Providence 1, Rhode Island.

Model DVS



Model CVS

BUILDERS PRODUCTS

The Venturi Meter • Propelofio and Orifice Meters • Kennison Nozzles • Venturi Filter Controllers and Gauges • Conveyoflo Meters • Type M and Flo-Watch Instruments • Wheeler Filter Bottoms • Master Controllers • Chlorinizers — Chlorine Gas Feeders • Filter Operating Tables • Manometers • Chronoflo Telemeters

BUILDERS-PROVIDENCE *Instruments*

130 YEARS 1820 BUILDERS 1950 BUILDERS IRON FOUNDRY

(*Continued from page 66*)

mchy. to be housed. Aim of modern indus. architecture to design building as tasteful as expenditure will allow. Apart from aesthetic considerations, these points to be considered: likelihood of addnl. pumping unit; mchy. entrance door with width and height to enable truck with engine to back into room; internal window sills sloped to prevent articles from being placed on ledge; enginehouse floor paved with adamant tile; wide rather than deep trenches for pipes preferable in enginehouse floor; exhaust pipes not permitted to disfigure building; workshop provided; foreman's office situated in position for easy access to enginehouse; greater consideration than in past given to working conditions and convenience of workers. Separate messroom with adequate cooking facilities provided. Elimn. of noise and efficient space heating matters for joint consideration of architect and engineer. Architect in design should endeavor to convey message which corresponds with purpose of filter house. In general, same amenities should be provided as at pumping stations.—*H. E. Babbitt.*

DAMS AND RESERVOIRS

Construction of the Claerwen Dam. City of Birmingham Water Works. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **53**:213 (May '50). Work commenced in '46. Dam concrete gravity section, curved in plan to 2000′ radius, 184′ high, 1066′ long at top water line, and will impound 10,800 mil.gal. (Imp.) in reservoir 4½ mi. long. Overflow, situated centrally in dam, 540′ long, with estd. discharge of 5800 cfs. at 3′ depth over spillway. Drawoff provided at 2 levels by 4 36″-diam. pipes leading to 24″-diam. sluice valves and finally to two 48″-diam. needle valves. Foundation, with max. width of 180′, has been taken 10′–15′ into sound rock at downstream toe, and sloped down therefrom at 1:24 ratio toward upstream side where cutoff trench excavated. Bids called for concrete dam with brick-and-masonry-faced, precast concrete block facework and ashlar masonry above; concrete dam with brick and masonry facework built *in situ;* and concrete dam with downstream facework in plain concrete. Lowest bids, respectively: £1,494,440, £1,464,394 and £1,392,800. Quarry for production of concrete materials opened about 4 mi. from site. Concrete mixed in one 3-cu.yd. tilting-drum Winget batch mixer, with rated output of 120 cu.yd./hr. During constr. of central portion of dam, river diverted into channel 820′ long, about 130′ east of original bed. Dewatering of main excavation carried on by one 10″ centrifugal pump. Drilling and blasting of rock done vertically and horizontally using 50% gelignite detonated electrically. Drilling for grouting done through vertical pipes after concreting cutoff trench, by air drilling using diamond bits in stages of 10′–15′ to max. depth of 100′. Work organized in one shift from 7.15 A.M. to 6 P.M., including two half-hour meal breaks. Labor strength varied between 300 and 350 men. In view of danger of poln. to existing water supply, none of labor or staff housed within catchment area. —*H. E. Babbitt.*

Design for the Raising of Mundaring Weir. V. C. MUNT. Wtr. & Wtr. Eng. (Gt. Br.), **52**:391 (Aug. '49). Raising of weir one of major works required in scheme for reticulating water to farms and for domestic purposes in mixed farming dists. of Western Australia, as well as increasing supply to Eastern Goldfields areas for expansion of gold mining industry. Mundaring Weir, or Helena Res. as formerly known, mass concrete structure on Helena R. in Darling Range. Structure 100′ high with crest length

(*Continued on page 70*)

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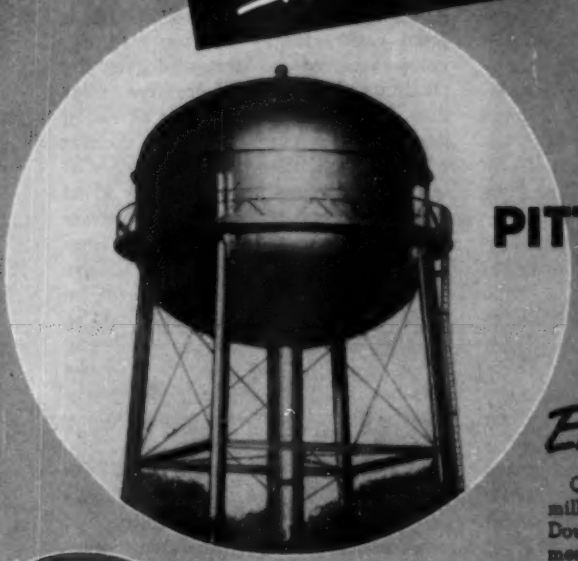

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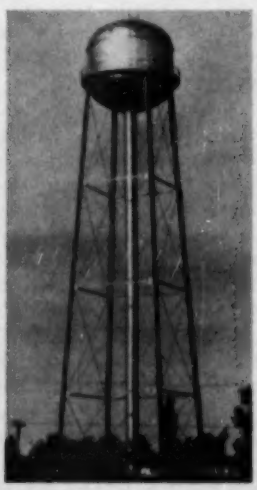

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(Continued from page 68)

about 700'. Most important gravity dams that have been raised are Assouan Dam in Egypt and O'Shaughnessy and Alpine dams in California. Basic design assumptions: [1] new and old walls monolithic; [2] ordinary gravity anal. sufficient, especially since it is intended to use free contraction joints without vertical keyways; [3] all loads resisted by gravity action of vertical cantilever elements having parallel sides 1' apart; [4] unit vertical pressures assumed to vary linearly from upstream face to downstream face of dam; and [5] horizontal shear stresses assumed to have parabolic variation across horizontal planes from upstream face to downstream face of dam. Boreholes in dam indicated number of weak planes subject to severe uplift. Highly improbable that any one weak plane extends over great area. Leakage through wall appears at comparatively few moist places on downstream face. Design data: unit wt. of concrete, 145 lb./cu.ft.; max. allowable compressive stress in concrete, 500 psi.; ultimate strength of concrete in shear, 400 psi. for new, and 200 psi. for old; coefficient of friction, concrete on concrete or on rock, 0.70; modulus of elasticity of new concrete, 3,400,000 psi.; stability factors—overturning factor of safety 1.5 min., sliding factor 0.8 max., shear friction factor 5.0 min. Temp. changes that occur in interior of large mass of concrete may not be sufficient to cause formation of crack. While mass concrete rising in temp. after being cast, it changes from soft yielding material, with no resistance against plastic deformation, to hard, semielastic material. Little or no expansion permitted during early period of rising temp. Only moderate degree of compressive stress develops because of plastic nature of young concrete. When concrete becomes more resistant it cools, while underlying material then acts to prevent it from contracting. Tension that develop relieved to lesser degree by plasticity than was compressive stress that developed during period of rising temp. If new concrete cast in contact with old wall, then, in early stages of setting and temp. rises, there is great restraint to expansion on new concrete at joint. It becomes obvious that free-sliding joint would be desirable. Method of analyzing structure, given in some detail, believed to be original. Before proceeding with concreting above existing overflow level, joint will be sealed and no further movement will be able to take place along it. Max. foundation stress 170 psi., occurs at heel of new wall when joint frictionless. Rate of cooling of mass of concrete complicated problem, of vital importance in Mundaring project. Effect of seasonal changes in temp. neglected because there would not be much concrete placed at more than 15°F. above or below annual mean. Unit strain prevented comparable to effect of 9°F. temp. difference between new and old concrete. Minor cracking to be expected in vicinity of joint but possibility of failure in bond between 2 surfaces remote.—*H. E. Babbitt.*

Nottingham Corporation Water Department. Swingate Reservoir and Water Tower. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **53**:128 (Mar. '50). Swingate reservoir and water tower provides further link in chain which brings water from Derwent Valley to Nottingham. Reservoir needed to provide storage lost by failure of reservoir at Watnall through fractures caused by colliery workings. Site of Swingate Res. covers area of 10.6 acres; dimensions 231' by 204' 8", with working water depth of 14'. Floor constructed of mass concrete, with concrete slabs in squares of 247

(Continued on page 72)

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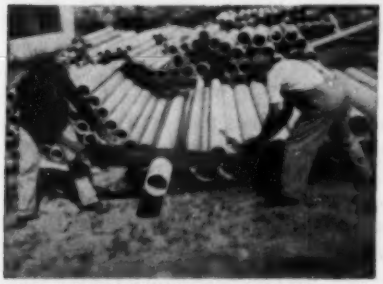

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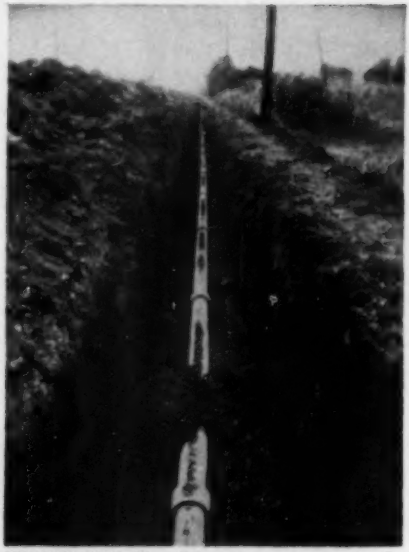

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(*Continued from page 70*)

sq.ft., 4″ thick. Gap of ½″ left between squares, later filled—bottom 2½″ with cement grout, remainder with bituminous compd. Roof slab 4½″ thick covered with 4″ gravel and 8″ soil, seeded with grass and mixed clover. At pumping station, water withdrawn by either of two 500-gpm. (Imp.) pumps and forced into elevated tank 75′ higher than reservoir. Tank square, 30′ on each side and depth of 15′ to top water level. Main laying carried out under 3 separate contracts; first consisted of 1321 yds. of 18″ main; another, of 3499 yds. of 18″ main; and third, of 5123 yd. of 15″ main. Total cost of work estd. at £137,684.—*H. E. Babbitt.*

WELLS AND GROUND WATER

Experiments on the Continuous Disinfection of Dug Wells. ALEKSANDER SZNIOLIS. Gaz, Woda i Tech. Sanit. (Poland) **24**:60 (Feb. '50). Description given of app. designed for continuous chlorination of dug wells. App. consists of outer cylinder with 2 horizontal partitions on which bottle contg. chlorine soln. supported in inverted position. Bottle has rubber stopper in mouth and glass tube, end of which immersed in glass utensil (glass, beaker, etc.) maintg. const. level in this utensil. Glass siphon tubes contg. nylon thread which carry chlorine soln. hung from this utensil. Chlorine dosages varied by size and number of nylon threads used. App. designed to fulfill following criteria: [1] dependable operation without supervision for periods of at least 6 mo.; [2] proportional doses of small quants. of chlorine and daily dose of a 1% sodium hypochlorite soln. to be from 10 to 50 ml. of soln.; and [3] simple and cheap constr. for use in rural areas. Mechanical devices will not be satisfactory from standpoint of cost and because of ease of deterioration in moist atmosphere within well. Results reported for 2 wells treated by means of above app. in Wroclaw area. These show that wells may be satisfactorily chlorinated by this means. Prior to installation of app., following suggested: [1] det. chlorine demand of water in well; [2] chlorinate well to satisfy chlorine demand; [3] adjust app. to deliver necessary dosage of chlorine; and [4] check water for bact. count. Some practical difficulties encountered: dose rate from single nylon thread so small that it was necessary to use up to 9 threads simultaneously, dose rate dependent upon temp. of soln. and environment, dose rate dependent on position of const.-head level, and deterioration of nylon thread under field conditions. In lab., thread remained effective for 7 mo. whereas

(*Continued on page 74*)

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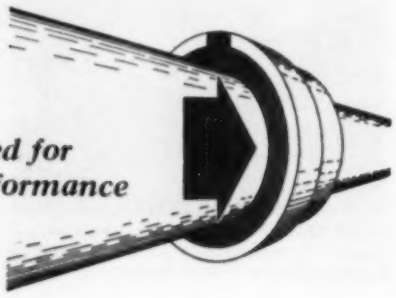

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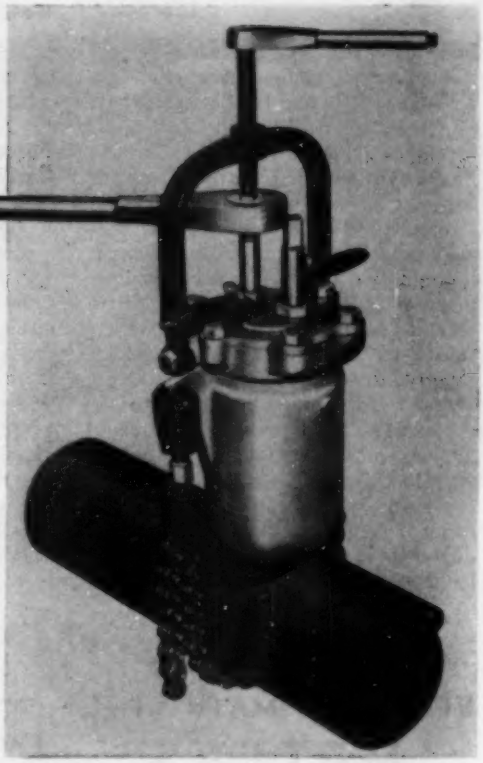

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(Continued from page 72)

in field its life was 2–3 mo. In conclusion author states that studies carried out in 1948 and 1949 indicate that: [1] possible to chlorinate dug wells continuously even though wells continuously contamd. from outside sources; [2] this simple and inexpensive method may radically change water supplies in rural areas and small communities which do not have access to municipal supplies and must therefore depend upon dug wells as their source of supply; [3] addnl. studies required to det. kinetics of chlorination and for setting amt. of chlorine required; [4] addnl. studies required to improve dosing device, or for replacing it with more suitable unit; and [5] rural areas in which typhoid is endemic and which are dependem upon dug wells for their water supply should be treated first. Bibliography appended, listing 33 Polish sources and 69 foreign references to literature on chlorination.—*Conrad P. Straub.*

Percussion Drilling With Tungsten Carbide Tipped Bits. E. J. WELLS. New Zealand Eng., p. 862 (Oct. '49). In last 3 yr. considerable advances made in use of tungsten carbide bits for percussion drilling of rock. Although tungsten carbide inserts fairly strong and will withstand shock loads provided they are well supported, there is limit to power of blow they will withstand without shattering. Anal. of forces sustained by carbide inserts given by author, from which it follows that main problem when considering use of carbide-tipped bits is to decide how hard they may be hit, with reasonable margin of safety, before breaking up. Pure tungsten carbide

(Continued on page 76)

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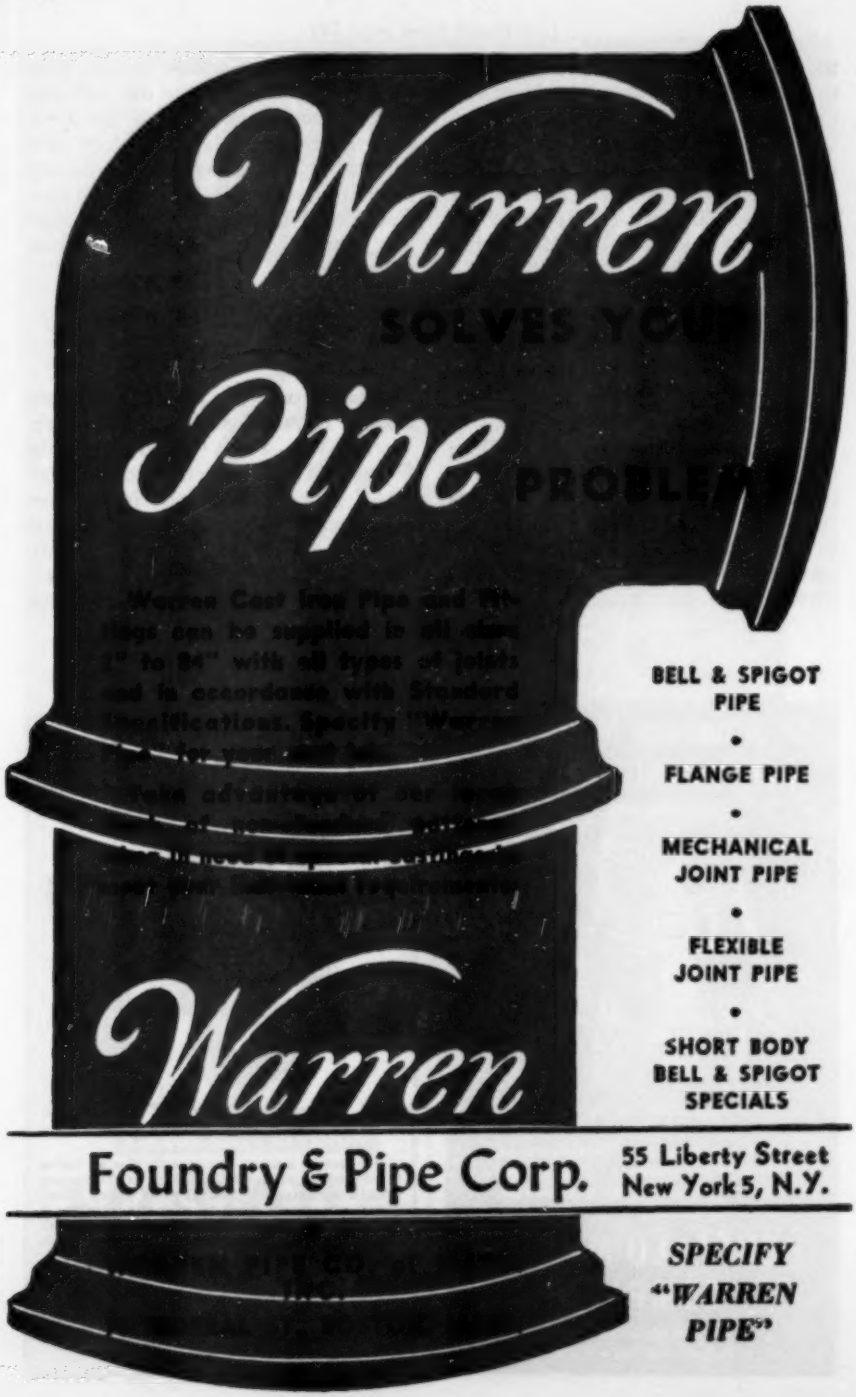

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too brittle for any useful purpose, and to give it strength it is powdered and mixed with cobalt before final sintering. Varying percentages of cobalt give differences in hardness and strength of final product—as shown in table given in article. It has been found that tungsten carbide inserts varying in hardness from 89.0 to 91.0 Rockwell A generally give best results. For comparatively soft rock, less costly 2-point or chisel bits quite suitable and, indeed, often have penetration speeds faster than 4-point bits. In hard work, cruciform or crossbits preferred. Recommendations for typical rocks given. Author then discusses effect of air pressure used on rock drill's performance, characteristics and energy losses incurred. Test results with tungsten carbide bits given for impact loadings less than 8000 lb. and for loadings greater than 8000 lb. Worthy of note that soft and medium-hard rocks, which by abrasion render conventional steel or steel detachable bits impotent within foot or so, drilled readily by tungsten carbide bits with remarkably little gage loss and reduction in penetration speed.—*Ed.*

INSTRUMENTS AND APPARATUS

Fundamentals of Automatic Control of Liquid Level. LEO WALTER. Wtr. & Wtr. Eng. (Gt. Br.), **52**:556 (Nov. '49). Measuring elements fall into 2 groups; direct and indirect, or interferential, measurement. Basic elements for main group are floats, displacers and floating tanks. Pressure gages used for measuring liq.

(Continued on page 78)

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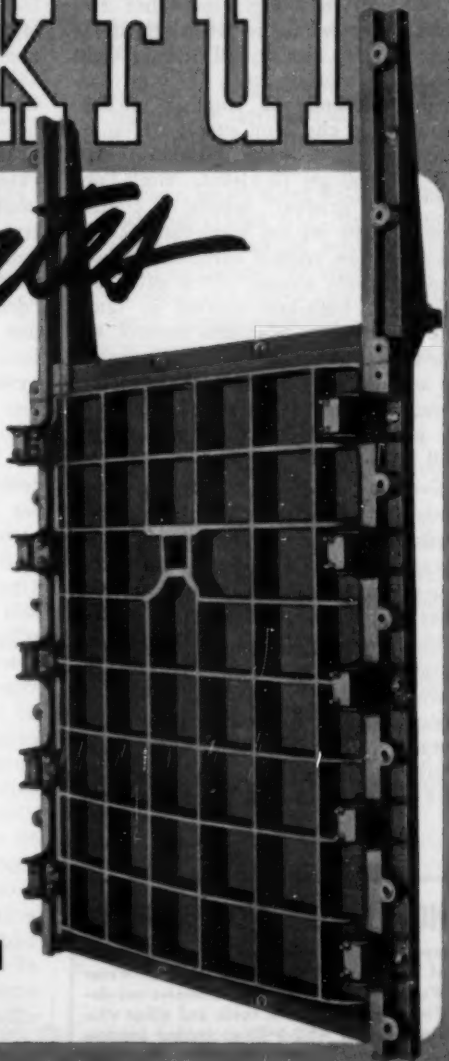

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(*Continued from page 76*)

height hydrostatically. Use of air bell with flexible diaphragm common in measurement of liq. level in tanks. Indirect measurement popular. Typical design uses elec. resistance element immersed in liq. Change of resistance with rise or fall of liq. height produces measurement. Choice of method depends on whether purpose is either to check on supply of liq. to reservoir, to ascertain correct storage vol., or indicate liq. level. Both "on-off" and "gradual" modes of control can be used for liq. level control. In on-off action, control valve either fully open or fully closed. It is often applied for high-low control in tanks and reservoirs. Gradual control applied where liq. level avg. desirable. In on-off mode of control, level differential must be permissible and, at or near low level, valve admits liq. full bore until high level reached and valve closes. Most widely used controls for smaller tanks are liq. level switches. Where water or oil under pressure is outside source of power for operating control mechanism, it is possible, by using hydraulic cylinders with power piston, to exert large forces for movement of large butterfly valves or gate valves. Wide use of compressed air instead of water under pressure. Second main group of controllers provides gentle, metering control action of control valve, and valve movement and rate of flow of liq. will be continuously varied, according to demand. Best example of floating mechanism is motorized valve actuated from level switch. Most widely used method for simple control problems uses float mechanism with control valve. Proportional mode of control introduces term "proportional band" or "throttling range"—range required to move valve from fully open to fully closed position. Phenomenon which occurs with proportional mode of control, and with all forms of gradual control having proportional component, called "offset," "droop" or "drift"—wandering of control point due to sudden disturbance of process load. Magnitude of offset depends on system demand, and its direction opposite to change of demand or load. Simplest form of proportional controller is universally used cold-water cistern with lever float valve. Controller types developed which combine stable quals. of proportional control with speeding-up influence of floating type. Some controller mechanisms add corrective action automatically if offset develops. For delicate processes, such as control of chem.-reaction vessels where even slight fluctuations of level would be detrimental, accelerated reset action can be produced by more elaborate control mechanisms called "stabilized" or "rate mechanisms." Level control of open tank or closed vessel where max. possible supply and demand near to each other necessitates very responsive control action. Stabilized controllers have advantage in that they react from start of control impulse and vigorously counteract even slight development of offset.—*H. E. Babbitt.*

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(*Continued on page 80*)

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(*Continued from page 78*)

passing through pipe, siphon or covered channel. When diam. of inlet and outlet of nozzle known, pressure measured at test place in pipe and at reduced nozzle outlet. Pressure measurements accurate within 0.33–1.65%, depending upon diam. of pipe or flow; in siphons, accuracy within 0.5–0.7%.—*Willem Rudolfs.*

TREATMENT—GENERAL

Settling as Part of Water Purification. N. D. R. SCHAAFSMA. De Ingenieur (Neth.), **4**:1 ('50). Formula developed for relation between observed settling rate, absolute settling rate and concn. of hydrated floc suspensions obtained in water purif. Formula applicable to suspensions with concns. lower than 0.71. Flocs conceived as globular with same diam. Formula may be written as ratio of thickness of layer of compacted sludge, obtained after 3 days settling, to height of regional suspension column multiplied by constant. For ppt. obtained by bringing alum in water to pH 6.4, constant is 4.—*Willem Rudolfs.*

Use of Organic Colloids as an Aid to Coagulation. C. GOMELLA. L'Eau (Fr.), **37**:4:57 ('50). Marseilles' water supply obtained from canal, low in $CaHCO_3$, colorless, odorless, without organic matter but high in turbidity due to lime and silica crystals. Suspended matter extremely fine, forming stable colloidal suspension difficult to remove by coagulation. Addition of starch waste, starch suspensions or sodium alginate increases size of flocs formed, enhances settling and filtration. Quantity of aid used depends upon character of water to be treated.—*Willem Rudolfs*

A New Method for Single Rapid Filtration. H. A. D. LINN. Water (Neth.), **34**:19 (Feb. 2, '50). Pilot plant expts. based on principle of tur-

(*Continued on page 82*)

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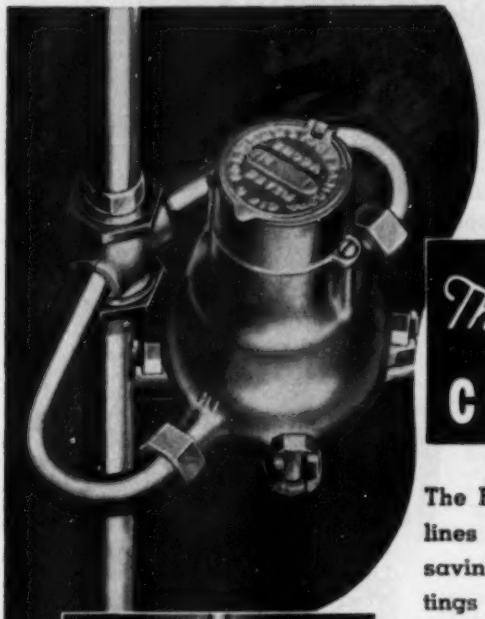

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(Continued from page 80)

bulent flow, and aeration with aid of venturi tube, have shown that very effective oxidation of undesirable material can be accomplished in short time. Oxygen in soln. brought into filter. In present methods filter covered with water (wet filter) and only 12 ppm. O_2 available for oxidation. Passing filter medium (dry filter), more oxygen becomes available and better results obtained. When complete oxidation of undesirable material required, air or oxygen can be applied under pressure upward from bottom of filter and all NH_4, Fe, and Mn can be oxidized in one passage. Sand used 1.25–2 mm. in diam., sand depth 53″, rate of flow 9.8 ft./hr., filtration time 100 hr. Results after single passage through "dry filter":

Substance	Raw Water *ppm.*	Effluent *ppm.*
NH_4	6–7	± 0.1
Fe	1.5	0.07
Mn	0.15	0.06
O_2	0	± 10

"Dry filters" need only half surface area of "wet filters" with probably 40% reduction in construction cost and longer filter runs.—*Willem Rudolfs.*

CHEMICAL ANALYSIS

New Test for Free Chlorine or Bromine. R. F. MILTON. Nature, p. 448 (Sept. 10, '49). Test put forward which is specific for free chlorine (only free bromine reacting in similar way) and approx. twice as sensitive as tolidine reagent. It is based on reaction of free chlorine with cyanides to form cyanogen chloride. This cyanogen chloride then allowed to react with pyridine soln. contg. also benzidine hydrochloride whereupon colored di-anil derivatives ultimately produced. To 5 ml. of water sample is added 1 ml. of 1% soln. of sodium cyanide, this followed by 5 ml. of 25% soln. of pyridine contg. 2% benzidine hydrochloride. In presence of free chlorine, reddish color fully developed in 10 min.—*B.H.*

Indicators for the Determination of the Chlorinity of Water. MILJENKO BULJAN. Acta Adriatica, **3**:383 ('48–'49). End point errors in titration of chloride with $AgNo_3$ soln. detd. with K_2CrO_4, Na_2AsO_4 and fluorescein as indicators. No error found with fluorescein if chloride concn. kept between 0.006 and 0.053*N* to prevent coagulation of AgCl ppt. Two ml. of 1% soln. of gelatin added to 15 ml. of sea water plus 30 ml. distd. water also prevented coagulation. Endpoint error with Na_2AsO_4 greater than that with K_2CrO_4 as indicator.—*C.A.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Metallizing Makes an Old Water Tank Like New. J. E. WAKEFIELD. Eng. News-Rec., **145**:1:40 (July '50).

An Open Reservoir Free of Algae. Eng. News-Rec., **144**:20:41 (May '50).

Bold Triple Chlorination Now Standard Practice at Attumwa. H. A. BROWN. Wtr. & Sew. Wks., **97**:7:267 (July '50).

Erratum

In the boldface title heading the 1948 annual report of the Erie Bureau of Water, abstracted in the June 1950 JOURNAL (Vol. 42, *Condensation* p. 60, column 1), the location of the city was given as New York. The correct location is Pennsylvania.

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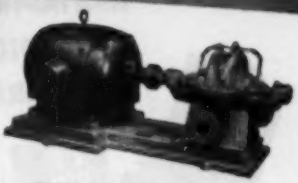

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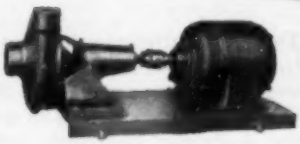

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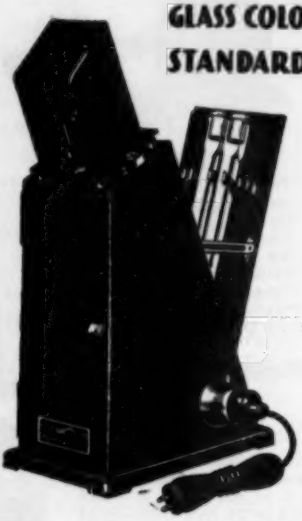

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"Let's Consider Your *Whole* Water Problem" describes the industrial water engineering services offered by Hall Labs., Inc., Hagan Bldg., Pittsburgh 30, Pa.

Pressure operated pump controls for elevated tank systems are the subject of a new bulletin on Autocon Mototrols, available from Automatic Control Co., St. Paul 4, Minn.

A 68-page bulletin on Nordstrom Valves has been issued showing numerous installations of the valves in oil and gas transmission. Information on the design features of their plug valves is also included by the organization, a division of Rockwell Mfg. Co., Pittsburgh 8, Pa.

Two new bulletins issued by Hungerford & Terry, Inc., Clayton, N.J., are available on request. Bulletin BFT-1 is a 20-page survey of external boiler feedwater treatment, including softening and silica removal equipment. Bulletin DM discusses various types of demineralizing equipment, including the Un-a-Bed deionizer.

A new IMO rotary screw-type pump for pumping light viscous fluids is described by De Laval Steam Turbine Co., Trenton 2, N.J., in Bul. L313A-B.

The complete line of cast iron, malleable and bronze fittings offered by Kennedy Valve Mfg. Co., Elmira, N. Y., is described in a new bulletin, No. 104, which is available for the asking.

(*Continued on page 86*)

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(Continued from page 84)

Two new leaflets issued by Calgon, Inc., Hagan Bldg., Pittsburgh 30, Pa., concern the prevention of lime scale and the stabilization of lime and manganese. The pocket-size pamphlets present case histories of the use of Calgon for various purposes.

The Foster "Flow Tube" is described as a new primary element for fluid flow measurement and control in a booklet available from Foster Eng. Co., 835 Lehigh Ave., Union, N.J. The tube is a short spool piece containing two groups of nozzles pointing in opposite directions and interconnected by common pressure rings to which conventional metering or recording devices may be attached.

A pollution- and frost-proof outdoor drinking fountain is described in a folder issued by Murdock Mfg. & Supply Co., 426 Plum St., Cincinnati 2, Ohio. The fountain is of metal construction and employs foot-pedal valve operation.

Atlas Mineral Products, 42 Walnut St., Mertztown, Pa., has issued a description of its complete line of chemical construction materials, including corrosion-proof surfacings and handy estimating data. The booklet is known as General Bulletin MCC No. 1.

(Continued on page 88)

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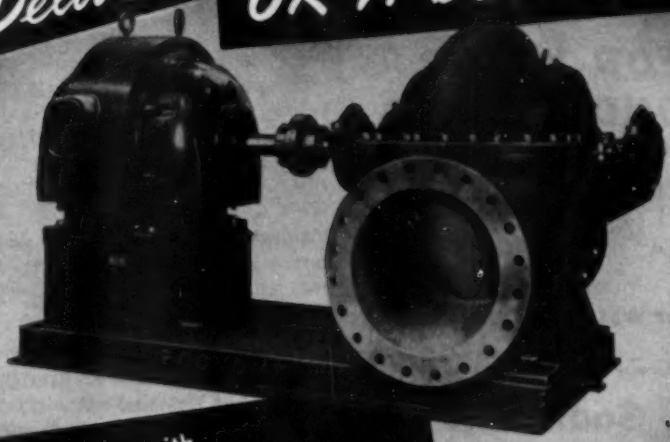

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Chlorine . Ammonium Chloride

(Continued from page 86)

Porous filter elements of stainless steel are the subject of a booklet issued by Micro Metallic Corp., 193 Bradford St., Brooklyn, N.Y. Pore openings of the sheet steel range from 5 microns for the superfine to 165 microns for the extra coarse. The metal is formed by fusing stainless steel powder at a temperature just below the melting point. Flow capacities of up to a maximum of 300 gpm. per square foot of extra coarse filter element in the $\frac{1}{8}$-in. thickness, with a pressure drop of 2 psi., are claimed—and twice that for $\frac{1}{16}$-in. filters. Information on Surfamax Filters employing the porous steel elements is also included.

"Amberlite Monobed Deionization" is the title of a 12-page booklet issued by Resinous Products Div., Rohm & Haas Co., Washington Square, Philadelphia 5, Pa. The booklet offers a basic grounding in the theory and applications of combined cation- and anion-exchange in the production of high quality demineralized water.

Polyphase electric motors manufactured by A. O. Smith Corp. are the subject of a new bulletin, No. EM4-812. Copies are obtainable from the Motor Div. of the company, Los Angeles 22, Calif. The motors range from 1 to 75 hp.

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Pipelines, Submerged:
Boyce Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mchy. Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

FASTER! FASTER! FASTER!

The Permutit® Spiractor®—last word in Cold Lime Soda Treatment—softens water in EIGHT MINUTES!

The Spiractor softens water up to 20 times faster than previous cold lime soda methods. That means you can cut your space requirements to a minimum!

Operation of the Spiractor is simple and sure: Hard water and the required lime enter at the base of the cone at a flow rate strong enough to suspend a catalyst bed of calcium carbonate granules without any carryover. The treated water is given a swirling, upward motion by being admitted tangentially to the cone.

The water softening reaction results in precipitates which are deposited on the catalyst granules by accretion. The enlarged granules are drawn off by a valve at the base.

The effluent is soft water that has a low alkalinity content and is suitable for any desired filtration.

Write for full information to The Permutit Company, Dept. JA-8, 330 West 42nd St., New York 18, N. Y., or to Permutit Company of Canada, Ltd., 6975 Jeanne Mance Street, Montreal.

WATER CONDITIONING HEADQUARTERS FOR OVER 37 YEARS

Permutit

Rate Analysis:
Recording & Statistical Corp.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Cochrane Corp.
Dearborn Chemical Co.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks; see Tanks

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Cochrane Corp.
Industrial Chemical Sales Div.
Infilco, Inc.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

Drury-McNamee & Porter specified TOREX *in color for filters as early as 1937*

DRURY-McNAMEE & PORTER, Consulting Engineers, Ann Arbor, Michigan, specified Torex Enamel Deep Sea Green in 1937 for the submerged concrete filter basins at Highland Park, Michigan. Applied that year, Torex still beautifies the concrete.

What Torex means to the client. A novel idea it was at the time, to paint submerged concrete with a cheerful color. Now most engineers recognize that Torex Enamel brings a sparkle to the water, a new beauty to the plant. Because of the tilelike Torex finish, the plant stays spotlessly clean almost without effort. Deputy Superintendent Vern Hinebrook, pictured above, says: "I'm really proud of my filter plant!"

Why does Torex last so long? Constant submersion in water does not soften the resistant rubber base. Nor do chemicals like soda, alum and chlorine. Torex remains tough and hard. It adheres firmly to the concrete. It never peels, blisters or powders off.

It's easy to specify Torex. Sample Specification: "All concrete submerged in water shall be painted with one coat of Torex Undercoater (1 gallon, 200 square feet) and one coat of Torex Enamel (1 gallon, 250 square feet) in a color to be selected by the engineer."

If you wish to speak with the local Inertol representative about painting specs, please drop a postcard to:

INERTOL CO., INC.

19 South Park
San Francisco 7, Calif.

480 Frelinghuysen Avenue
Newark 5, N. J.

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PITTSBURGH-EMPIRE
large capacity meters

RIGHT for the job — RIGHT on the job

Commercial, industrial and apartment house services are potentially big revenue earners. To get all this revenue you need the right type of meter on every job. Fitting the proper meter to the setting is an important part of Pittsburgh-Empire service. We alone make all types of water meters, thus we can give you our recommendations without prejudice and in your best interests. To get all the facts on how to collect all your revenue, write the nearest District Office.

PITTSBURGH DISC METER
LARGE CAPACITY TYPE
An all-bronze case meter made in sizes from 1½-in. through 4-in.

PITTSBURGH EUREKA "B" METER
CURRENT TYPE
Sizes 2-in. through 6-in. Measures the velocity of rapidly flowing volumes of water.

EMPIRE OSCILLATING PISTON METER
TYPE 16
The only oscillating piston water meter made in sizes from 1½-in. up.

PITTSBURGH-EMPIRE COMPOUND METER
SINGLE REGISTER TYPE
(Two Register Arctic-Tropic Compounds also available)
Performs basic functions of both a displacement meter and a velocity meter. Sizes 2-in. through 6-in.

Pittsburgh Equitable Meter Division
ROCKWELL MANUFACTURING COMPANY
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Atlanta Boston Chicago Columbus Houston Kansas City Los Angeles
New York Pittsburgh San Francisco Seattle Tulsa

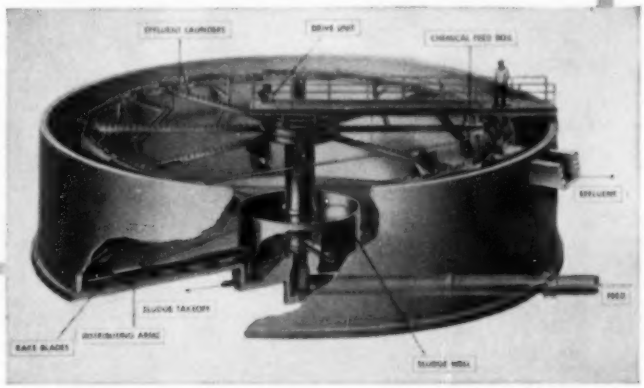
LET'S LOOK AT THE FACTS

when selecting HIGH-RATE units for industrial water treatment!

You want the best . . . when you select high-rate units for the removal of hardness, turbidity, color or algae from your process water.

Here are six basic reasons why you should select Dorrco Hydro-Treators . . . for the *best* results . . . at *lower* cost:

- ✓ Uniform, low turbidity effluent
- ✓ Exceptionally low moisture content in discharged sludge
- ✓ Positive, continuous sludge removal
- ✓ Low installed cost
- ✓ No "slug loading" on adjacent streams
- ✓ Minimum power requirements



THE DORRCO HYDRO-TREATOR

Overflow launder arrangement illustrated used on larger sizes. Arrangement varies with size of unit.

If you are investigating high-rate, up-flow type units for industrial water treatment, get all the facts before deciding. A Dorr engineer will gladly supply detailed figures and operating results . . . at no obligation.

DORR

RESEARCH ENGINEERING EQUIPMENT

DORRCO

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Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

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No Caulking